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PUBLIC NOTICES.

HEATING.

The Commissioners of His Majesty's Works, &c., are prepared to receive TENDERS before 11 a.m. on Thursday, 16th June, 1932, for ACCELERATED LOW-PRESSURE HOT WATER HEATING at the Head Post Office, Plymouth, Devon.

Drawings, specifications, a copy of the conditions and form of contract, bills of quantities, and forms for Tender may be obtained from the CONTRACTS BRANCH, H.M. Office of Works, King Charles-street, London, S.W. 1, on payment of One Guinea. (Cheques payable to the Commissioners, H.M. Office of Works.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. 8586

Civil Service Commission.

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Regulations and particulars, together with the forms on which applications must be made, will be sent in response to requests (preferably by postcard), addressed to the SECRETARY, Civil Service Commission, Burlington-gardens, London, W. 1, GIVING THE TITLE OF THE SITUATION. The latest date for the receipt of application forms is 7th July. 8517

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The Metropolitan Water Board invite TENDERS for the SUPPLY of the UNDERMENTIONED STORES and SERVICES, &c., for the periods of six and twelve months commencing 1st August, 1932 :—

Tender No.	
2	Brushes, Brooms and Handles.
5	Cotton Waste, Engine Wipers, Hemp, Rope, House Flannel, &c.
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24	Electric Lamps.

Tenders must be submitted on the official forms, which may be obtained on and after Wednesday, 1st June, 1932, from the Chief Engineer, by personal application at the offices of the Board (Room 155), or upon forwarding a stamped, addressed sack envelope. Applicants should refer to the number of the Tender for which forms are required.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board," and endorsed in the manner indicated in the form of Tender, must be delivered at the offices of the Board (Room 122) not later than 11 a.m. on Friday, 17th June, 1932.

The Board do not bind themselves to accept any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery-avenue, E.C. 1,
25th May, 1932. 8565

Skegness Urban District Council.
WATERWORKS DEPARTMENT.
CHARGE ENGINEER.

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Canvassing, directly and indirectly, will disqualify.

IVOR M.ᶜCULE,
Clerk to the Council.
8579

The Engineer

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PUBLIC NOTICES.

The Civil Engineers Appointments Board, 8, Princes-street, Westminster, S.W. 1, acting under annual licence from the London County Council, invites INQUIRIES from EMPLOYERS SEEKING the SERVICES of PROFESSIONAL ENGINEERS, either as Assistants or in more responsible positions.

All those whose names are accepted for entry in the Board's Register for employment possess qualifications which have been attested by means of scientific examinations, practical training, and experience. P2182

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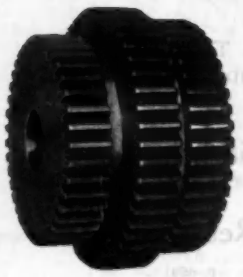

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For continuation of For Sale Advertisements see page 4

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Notice is hereby given that owing to the completion of the Lloyd Barrage at Sukkur large quantities of PLANT and MACHINERY as briefly detailed in the list below are now available FOR SALE.

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Most of the plant was purchased new for these works and it is in excellent condition. Every item of plant sold will be first overhauled and put in thorough working order before sale and will be open for inspection (and test wherever possible) by appointment at Sukkur.

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EXECUTIVE ENGINEER,
Y.6/5. PLANT DIVISION, SUKKUR. 8522

A Seven-Day Journal

Zuider Zee Reclamation.

LAST Saturday, May 28th, the great dyke across the Zuider Zee, from Nord Holland to Friesland, was completed, and the Zuider Zee became the Ysel Lake. The construction of this dyke was started in 1927. It is 18½ miles long and 120ft. wide at the top, while its width at the sea bed is about 400ft. The roadway and railway along the top of the dyke still remain to be constructed. Our readers will remember that we gave in illustrated articles in our issues of August 9th and 16th, 1929, some description of the complete scheme of reclamation. It will also be recalled that one of the four polders projected has already been reclaimed. This polder, known alternatively as the North-West, or Wieringermeen, covers a surface of approximately 50,000 acres. Several villages are now under construction in the area, one known as Slootdorp, consisting of thirty houses and a church. So far about one-fourth of the land area of the polder has been cultivated, the crops being mainly rye and oats. Large parts are under grass, on which cows and sheep are grazing. During the last few years we have recorded in a series of Journal notes the progress of the scheme of reclamation. It will be remembered that recently the Dutch Parliament decided, in view of the financial situation, to postpone the reclamation of the three other projected polders pending a full discussion of the matter. The closing of the great dyke, thus shutting out the North Sea, will make it possible to begin draining the land which is to be reclaimed.

Railway Pooling Scheme.

THE London, Midland and Scottish and London and North-Eastern Railway Companies have jointly submitted, for the consent of the Minister of Transport, under Section 19 of the Railways Act, 1921, heads of agreement for the pooling of receipts derived from passenger, merchandise and other traffic conveyed by rail in respect of which there is competition between the two companies. Section 19 of the Railways Act provides that before giving his consent to any such agreement the Minister shall, unless it appears to him that the matter is of such small importance that it is unnecessary to do so, refer the matter for consideration and report to a committee selected from the panel set up under Section 23 of the Ministry of Transport Act, 1919, as extended by the Railways Act, 1921. The Minister has accordingly appointed Sir Walter B. Clode, K.C., Herbert Edgar Parkes, and John Quirey, C.B.E., to constitute such a Committee, and has referred to them the above-mentioned heads of agreement for consideration and report to him. The Committee will sit on Tuesday, June 28th, to hear any representations or objections relative to the said heads of agreement.

British Engineering in China.

UNDER the style of "Dorman, Long and Associates (China), Ltd.," several prominent engineering concerns, whose manufactures cover almost the complete field of heavy engineering, have formed a company to promote the development of engineering projects in China. The constituent companies included in this scheme are: Dorman, Long and Co., Ltd., the Metropolitan-Vickers Electrical Export Company, Ltd., Babcock and Wilcox, Ltd., Callender's Cable and Construction Company, Ltd., Beyer, Peacock and Co., Ltd., the Tilbury Contracting and Dredging Company, Ltd., John I. Thornycroft and Co., Ltd., and Edgar Allen and Co., Ltd. The managing director of the new company will be Mr. Frank Freeman, who, it may be recalled, visited China last year on behalf of Dorman, Long and Co., Ltd., with the object of investigating its future as a possible field for British engineering activities. The company proposes, we understand, to place its collective resources in technical information and advice at the disposal of the authorities in China with the object of bringing to fruition such projects for public works as railways, electric power schemes, harbours, &c. It is believed that the ability to take over full responsibility for large schemes by a single group of firms will greatly help to crystallise undeveloped projects into a more concrete form, and may possibly enable schemes to be financed which otherwise might remain in abeyance.

The Trade Exhibition Ship Letitia.

IN a Journal note of January 12th, we referred to the proposal of the Anchor Donaldson Line to provide facilities on the s.s. "Letitia" for a trade exhibition of Scottish manufactures at Montreal for a week early in May. The "Letitia," which sailed for Canada early in May, reached Glasgow on her return voyage on Monday last. It is reported by the Duke of Montrose, its president, that the Trade Mission was a great success and justified itself in every way. Over 40,000 Canadians visited the ship at Montreal, and it is estimated that the total amount of business transacted, along with that in course of completion, will amount to over £250,000. An indication of the success of the visit is the number of business men who have found it advantageous to stay in Canada and pursue their inquiries, returning on a later liner. The chairman of the mission, Mr. George A. Mitchell, is one of this number. Particular interest attaches to the statement which has been made by Mr. John Craig, the managing director of Colvilles, Ltd., of Glasgow, who personally visited many of the Canadian steel works. Mr. Craig is of the opinion that the Canadian steel works are not in a position to meet the complete demands of Dominion users. At the present time, he says, America is supplying the main requirements, but with the currency difference, the preference given to British manufacturers by Canada, and the assistance of the shipping companies, it is possible for Scottish and English makers to deliver steel in Eastern Canada at prices strictly comparable with those of the United States steel makers. Canadians, however, he points out, are accustomed to American standards, and this factor must be taken into account. Mr. Craig looks forward to the time when the steel works of Great Britain will ultimately supply the great bulk of Canada's requirements.

Britain's Year of Opportunity.

IN writing to Viscount Leverhulme to wish success to the Annual Advertising Convention, to be held in Liverpool from June 11th to the 15th, the Chancellor of the Exchequer, Mr. Neville Chamberlain, comments on the general items chosen for discussion. "Britain's Year of Opportunity," which is a comprehensive variant of the phrase "England's Year of Opportunity," which the Chancellor used in a recent speech. Mr. Chamberlain says that in speaking of the year 1932 as our year of opportunity, he had particularly in mind two things. First, that we had already re-established our own confidence in ourselves, and our position in the eyes of the world; and, moreover, were then about to pass into law measures for the protection of our producers in the home market; and secondly, that, building on these duties upon foreign imports, we should presently be entering upon an Imperial Conference at which, for the first time in our history, we should be able to meet the other partners in the Empire with offers of preference for their products, in return for similar preferences upon our exports to them. In his opinion, these conditions offer an unequalled opportunity for the expansion of our trade, both at home and overseas, and he had no doubt that our merchants, manufacturers, and agricultural producers would take full advantage of so favourable an opening, not forgetting that, without adequate publicity, the world cannot be expected to realise the superiority of British products.

The Late Mr. P. D. Ewing.

WIDESPREAD regret will be felt in marine engineering and shipbuilding circles by the news of the death of Mr. Peter Dewar Ewing, the managing director of J. Samuel White and Co., Ltd., of Cowes, Isle of Wight. Mr. Ewing died in Glasgow on Wednesday last, June 1st, at the comparatively early age of sixty-six, following an operation. He was born at Cambuslang, in Lanarkshire, and received his early education at Blantyre and at the Hamilton Academy. After leaving school he was apprenticed for five years to the shipbuilding firm of Aitkin and Mansel, Whiteinch. Later he became manager of the Ardrossan Shipyard, and he was also for some time a director and general manager of the Ailsa Shipbuilding Company, Ltd., of Troon and Ayr. When during the war it was decided to open a National Shipyard at Chepstow for the production of standard ships, Mr. Ewing had charge of the work. In recognition of his services to the country he was made C.B.E. in 1918. Between 1918 and 1920, when he went to Cowes, Mr. Ewing spent some time at Falmouth as the general manager of Cox and Co. (Engineers), Ltd. His work at J. Samuel White and Co., Ltd., included the adapting of the yard for mercantile work and the construction and repair of many noteworthy naval ships for the British Admiralty and for foreign Governments, many of which have been referred to in our columns. The loss of Mr. P. D. Ewing will be keenly felt by his own firm and by a wide circle of friends. He was a Member of Council of the Institution of Naval Architects and the Institution representative on the Tank Advisory Committee, and was prominently associated with the work of the Shipbuilding Employers' Federation.

Moisture in Timber.

THE Department of Scientific and Industrial Research issued during the week a Report prepared by the Forest Products Research Laboratory, written in very simple language, entitled "Determination of the Moisture Content of Timber." This quantity expresses the amount of moisture in a piece of wood as a percentage of the weight of dry wood in the sample. A knowledge of it is the only reliable way of telling whether wood is suitably seasoned for a particular purpose. Specifications for building timber usually state that it shall be "well" seasoned, or that it shall have been stacked for a definite period. But timber well seasoned for some purposes is quite unsuitable for others. Also, the degree of seasoning reached in a certain time is by no means a definite quantity. At present "rule of thumb" methods, such as feel and weight, are often used to judge whether wood is sufficiently seasoned. The Report shows clearly that determinations of the moisture content of samples of timber may be carried out quickly and easily. No costly or complicated apparatus is necessary, the essentials being a cheap balance for weighing the samples and an oven for drying them. Detailed plans are given of two simple types of oven which could be made in any workshop. The Forest Products Research Laboratory is strongly advising a wider use of moisture content as a guide to the suitability of wood for a particular purpose, especially in connection with timber specifications, which should state the actual content required. Once the simplicity and cheapness of this method compared with unreliable "rule of thumb" methods is appreciated, it is expected that the practice will extend greatly.

Waterloo Bridge.

BY a majority of no less than sixty-eight the House of Commons, on Wednesday evening last, June 1st, rejected the scheme of the London County Council for demolishing Waterloo Bridge and building a new bridge in its place, which was embodied in a Money Bill promoted by the Council. The result, which came as a surprise, was no doubt largely influenced by members who felt that national economy should be exercised on every occasion. The debate was opened by Sir William Davison, who moved that money be not voted and gave forcible expression to the case against the destruction of a bridge which, he said, was not only beautiful and historic, but sound and well suited, with necessary reconditioning, to meet modern traffic needs. When the present bridge could be economically repaired and adapted to carry four lines of traffic there was no justification for incurring three times the cost, as the London County Council proposed He submitted an estimate showing that Waterloo Bridge could be underpinned, the deformed arches repaired, and the structure corbelled out to carry four lines of traffic at a cost of £656,400. In comparison with this, the replacement of the bridge was estimated by the London County Council at £1,300,000, but there was good engineering opinion to support the belief that the cost would substantially exceed £2,000,000. This view was supported by Lord Baird and Mr. Duff Cooper. The case for the London County Council was stated by Sir George Hume, who deprecated the suggestion that there was a desire in any quarter to destroy Waterloo Bridge. The Council had, however, been warned by engineering authorities that the effective life of the bridge was coming to an end. While no engineer would say that the bridge could not be underpinned, it was asserted that immense cost and possible loss of life would be involved in the process. Mr. Pybus stated that the Government had reached the conclusion that they would not intervene in or obstruct a scheme for the demolition of Waterloo Bridge and its replacement by a new bridge if the London County Council decided that there was no alternative. With regard to the future, little can be said until the Improvements Committee of the L.C.C. has considered the situation. The general feeling seems to be that the Council will, after consideration, accept the decision of Parliament and proceed with as little delay as possible to prepare a scheme for the widening of the existing bridge to take four lines of traffic.

The Fruit Carrying Steamer Erin.

THE fruit-carrying steamer "Erin," which is owned by the Erin Steamship Company, Ltd., in association with the Standard Fruit and Steamship Company, and which was built and engined by Workman Clark (1928), Ltd., underwent successful trials last week. She has been specially designed for the carrying of passengers and fruit cargoes between ports on the Caribbean Sea and the Empire, and is propelled by a triple-expansion engine in combination with a Metropolitan-Vickers exhaust turbine installation. The ship has a measurement of about 6000 gross tons, and has a length of 431ft., a beam of 54ft. 9in., a depth of 33ft. 9in., and a loaded draught of 25ft. Under trial conditions a speed of over 18 knots was obtained. The main engine has cylinders of 28½in., 47½in., 57in. and 57in. diameter, with a stroke of 51in., and, together with the exhaust turbine, is designed to develop a maximum continuous service power of 6400 I.H.P. at about 90 r.p.m. The power developed in the D.C. generator of the exhaust turbine set is supplied to a propulsion motor having an output of 1820 S.H.P. mounted on the propeller shaft immediately aft of the main engines and the thrust block. A new feature is an auxiliary generator coupled to the main generator, which supplies about 200 kW for the fruit-cooling fans and other auxiliaries. When manœuvring or when working without the exhaust turbine arrangement three 70 kW Howden Sunderland Forge generator sets are available, any two of which machines can carry the maximum load. The boiler installation comprises five cylindrical return-tube boilers, designed for 260 lb. pressure and fired on the Todd system with Howden forced draught. The two-stage feed-heating system, and the main condenser embody the latest Weir practice.

CONSTRUCTION OF THE BENUE BRIDGE IN NIGERIA

(For description see opposite page.)

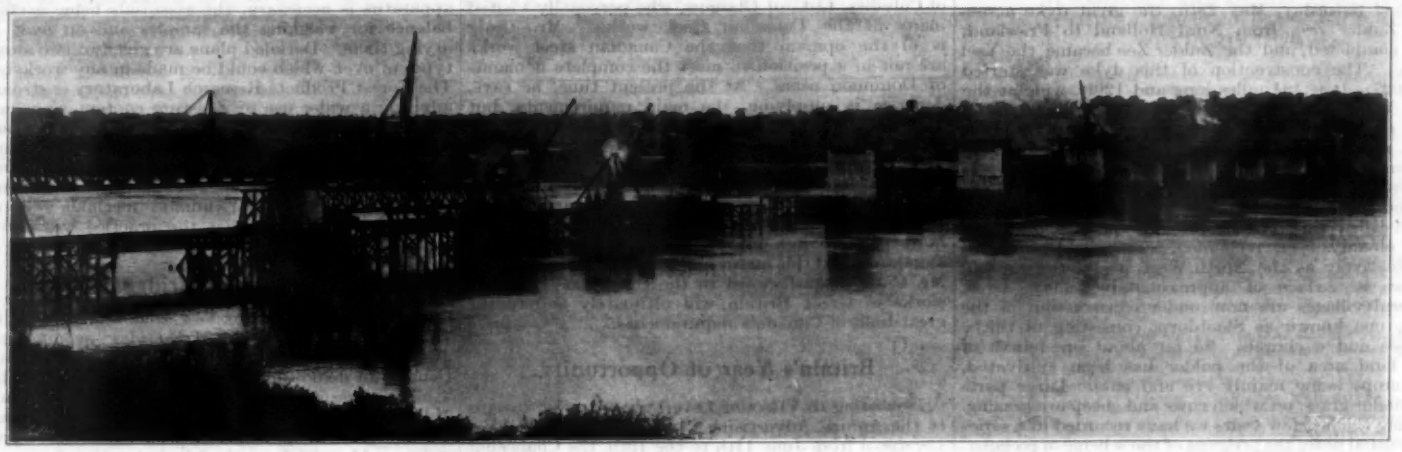


FIG. 11—VIEW FROM THE SOUTH BANK—JULY 8, 1931

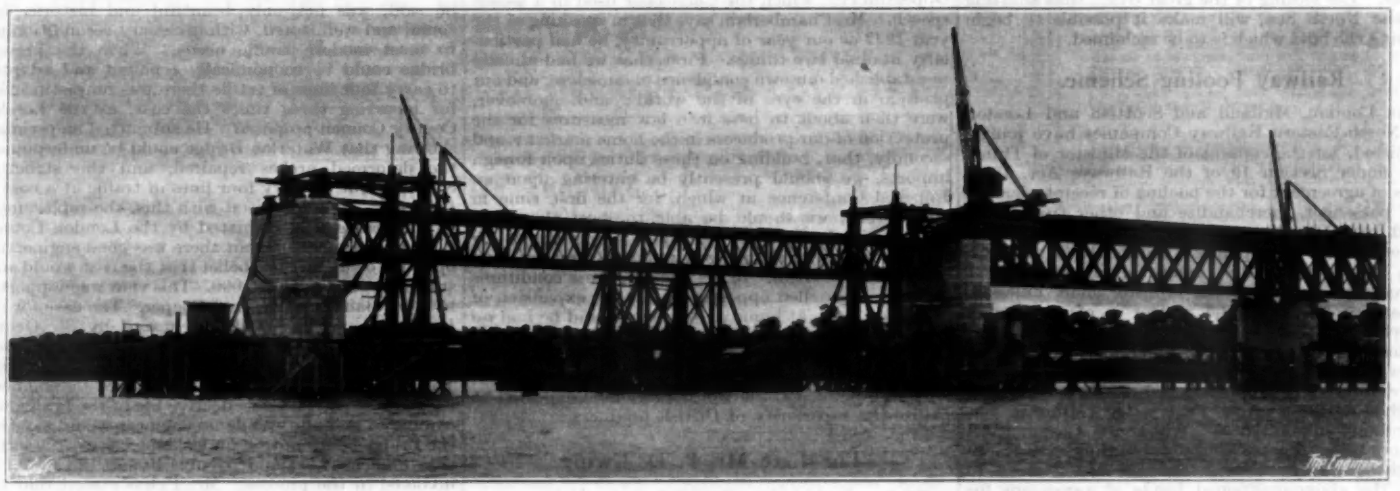


FIG. 12—ERECTION SPAN IN POSITION BETWEEN NO. 7 AND NO. 8 PIERS—JULY 11, 1931

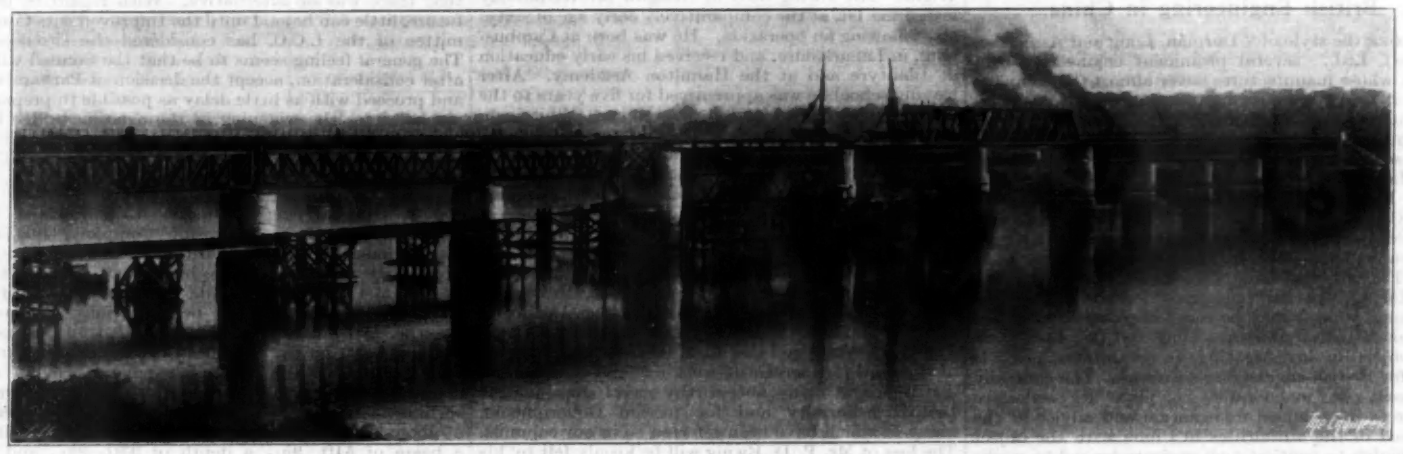


FIG. 13—VIEW FROM SOUTH BANK—FEBRUARY 3, 1932

FIG. 14—VIEW FROM DOWNSTREAM SIDE—FEBRUARY, 1932

The Benue Bridge in Nigeria.

No. II. (*conclusion*).*

Engineers: MESSRS. COODE, WILSON, MITCHELL, AND VAUGHAN-LEE, *in association with* MESSRS. MOTT, HAY, AND ANDERSON.

Contractors: SIR WILLIAM ARROL AND CO., LTD.

MAKURDI, at the site of the new bridge over the river Benue in Nigeria, is situated 550 miles north of the Equator, almost exactly on the eighth parallel. The climatic conditions are therefore tropical, while the district is regarded as unhealthy—at least for

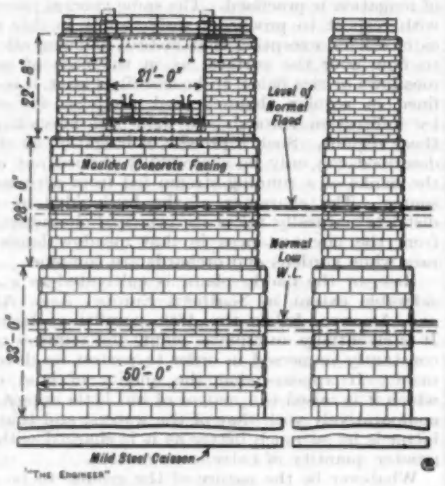


FIG. 15—PIER NO. 5

Europeans. In our last article we mentioned the unpleasant working conditions present while the caissons for the piers of the bridge were being sunk, but we made no reference to the general conditions under which the erection of the bridge had to be undertaken. In December and January the temperature of the district may fall to a minimum of about 60 deg. Fah. The lowest observed during the course of the erection work was 62 deg. Fah. The maximum experienced occurred in the month of March and was 105 deg. Fah. in the shade. Excessive rainfall never interrupted the work, since the average for the district is not heavy, and rarely exceeds 60in. per annum, most of which falls between April and November. From the beginning of the latter month to the beginning of the former there is little or no rain. The height of the water in the river varies, of course, with the rainfall, and consequently there are flood and low-level seasons. During the rainy season the river usually rose about 23ft. to 25ft., reaching the maximum flood level towards the middle of October. Subsequently it fell rapidly to its normal level. The flooding of the river had some influence on the erection work, since all the jetties and stages had to be built high enough to clear the flood level. Much vegetable matter and other *débris* was brought down by the waters at such times, and labour had to be employed continuously clearing away obstructions from the jetties and stagings. The maximum velocity of water flow observed was 6 miles per hour, which was sufficient to cause strong eddies and currents below the bridge. At such periods great care had to be observed when towing and manœuvring the temporary span, erected on the pontoons, into position between two piers. Other than flooding of the river, the only danger to be apprehended was from tornadoes, the wind force of which usually reached its greatest intensity in less than 10 minutes after the first warning. The maximum wind velocity recorded was 65 miles an hour. Tornadoes occurred towards the beginning and the end of the rainy season, and usually blew themselves out within the hour.

Except for British supervision, all the erection was carried out by African labour, which had to be trained to the various trades. In the early stages, to some extent owing to the language difficulty, this training was slow, but good progress was made later, and the men improved rapidly as they became more accustomed to the work. In all, over 1300 natives were employed. The maximum number of Europeans on the site at any one time was thirty-six. Generally speaking, the length of residence of Europeans in the country did not exceed fifteen months, but the time varied according to the nature of the employment. Very careful attention was directed from the beginning to the provision of proper housing accommodation, sanitation, and medical supervision, both of Europeans and natives, and this fact, combined with suitable catering and the provision of recreational facilities, probably accounts for the fact that although the work had to be carried on in an area generally regarded as unhealthy, the percentage of sickness was always kept satisfactorily low.

PREPARATION FOR THE ERECTION OF 240FT. SPANS.

The four central piers had all to be erected to a higher level than the others to carry the through spans. In Fig. 15 we give a drawing showing one of the piers which supports a 180ft. span on one side and a 240ft. span on the other, from which the arrangement of the bearings can be seen. Mention was made in the first article of the service jetty which was built along the upstream ends of the piers and formed a temporary road giving access from the shore for the transport of materials to each caisson and pier. Owing to the fact that a fairway had to be left open for traffic on the river, these jetties could not be carried out as far as the central piers Nos. 6 and 7, supporting the 240ft. spans. Consequently, materials for these piers had to be taken out in barges as required. A steam crane erected on the staging around the pier handled the material.

ERECTION OF THE 240FT. SPANS.

The erection spans previously used for the erection of the 180ft. spans were again used for that of the through spans. For this purpose they were lengthened from 164ft. to 221ft. by the addition of a section at each end. Each was then floated into position on the pontoons and raised by the use of hydraulic rams to the higher level required for the three central spans. As it was raised, braced trestles were erected on the existing stagings around the piers to support it, and a substantial piled structure was built up beneath its centre to ensure its stability during the season of flood and prevent undue deflection under the weight of the permanent span during its erection. The height of this trestle work from the river bed to the underside of the service span was about 75ft. in each case. Photographs taken at various dates and reproduced on page 602, illustrate stages of the work. In that taken on July 8th, 1931—Fig. 11—one of the shorter spans on the south side still remains to be completed, while on the north an erection span is being raised into position for one of the through spans. The photograph reproduced in Fig. 12 was taken three days later, and shows the erection span raised into position and the piled staging

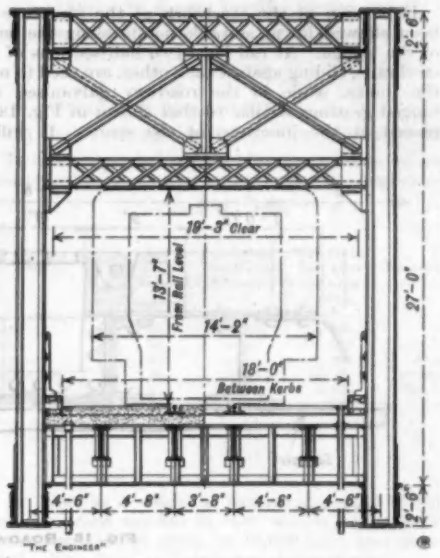


FIG. 17—CROSS-SECTION OF THROUGH SPAN

at the centre already erected. Other illustrations on the same page show the span between piers 7 and 8 complete, and the two erection spans in position for the erection of the remaining spans; and the erection of the central through spans completed. Two photographs reproduced on page 614 show panoramically stages in the work of erection at different dates.

The cranes used for the erection of the 180ft. spans were again used for the 240ft. spans. The portal structures upon which they were mounted for use on the smaller spans were, however, unsuitable for work on the through spans, and were consequently dismantled. Instead, the cranes were mounted on travelling bogie frames, the wheels of which were at 22ft. centres of track. They travelled upon rails laid on timbers, themselves supported by the bottom booms of the main span. They first travelled across, laying, as they went, the bottom booms of the main span, which were in 30ft. lengths, and on the return journey completed the erection of the rakers, posts, top booms, and portal bracings. The constructional features of these 240ft. spans can be seen from the drawings, Figs. 16 and 17.

When the riveting of the main structure had been completed and part of the deck steelwork had been put into position, the weight of the erection span was taken off the trestles by hydraulic rams supported on the main span. The trestles were then dismantled

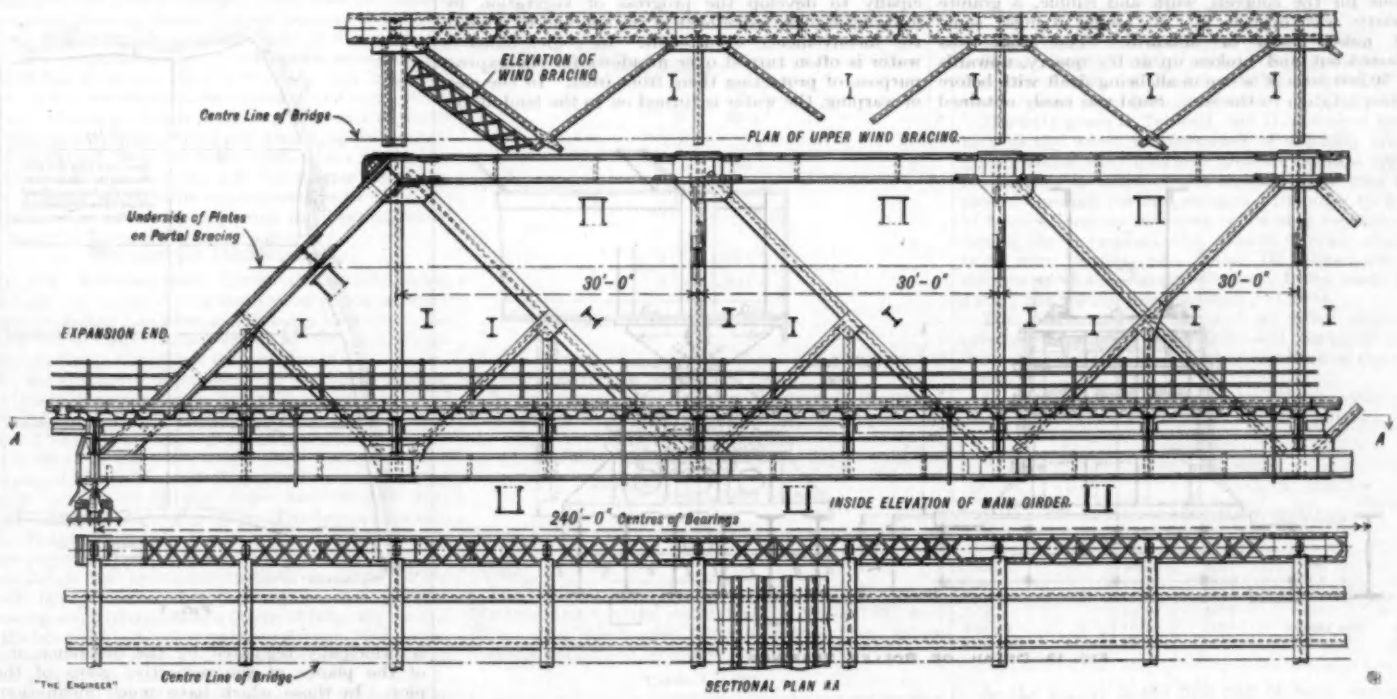


FIG. 16—CONSTRUCTIONAL DETAILS OF 240FT. THROUGH SPAN

* No. I. appeared May 27th.

and the erection span lowered on to the pontoons for transportation to the next bay or to the shore for dismantling.

The general arrangement of the decking of the longer spans is similar to that of the others, with the exception that the level of the troughing and the rails follows the rise of the camber of the booms. After the application of the full dead load, it was calculated that the rails and the roadway at the centre of the span would be higher than at the ends by 2¾in.

Allowance for Expansion.

Expansion of the steelwork of the structure has been allowed for at suitable points along the length of the bridge. At rail level two half-sections of cast steel rails, sliding against each other, are used to make the joints, while in the roadway galvanised steel hinged gratings similar to that shown in Fig. 18 are placed at the junctions of the spans. It will be

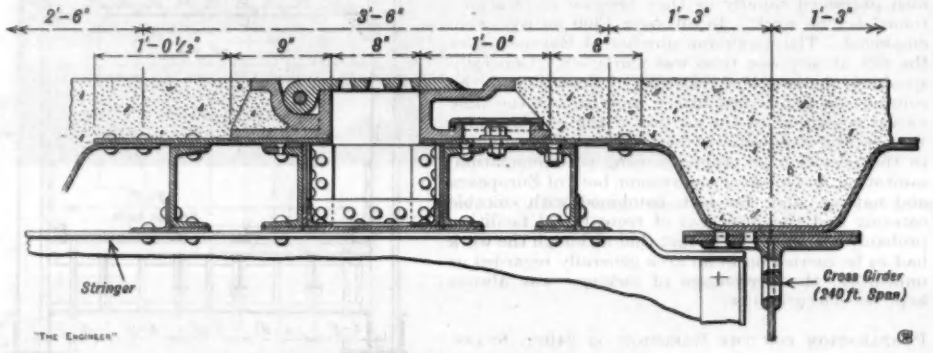


FIG. 18—ROADWAY EXPANSION GRATING

observed that the hinged lid can slide across the rebated frame. Each of the spans is carried in a fixed bearing at one end, while the other end is supported on rollers. One of these roller bearings is shown in Fig. 19.

Materials.

The whole of the plant, together with the materials required for the construction of the bridge, with the exception of the stone and sand required for the concrete, was sent out from this country, being shipped to Port Harcourt. Thence the materials travelled by rail, 289 miles, to the site of the bridge. To obtain stone for the concrete work and rubble, a granite quarry was opened up at Langa Langa, some 90 miles north of Makurdi. The stone was blasted out and broken up at the quarry, upwards of 50,000 tons of stone in all being dealt with before transportation to the site. Sand was easily obtained

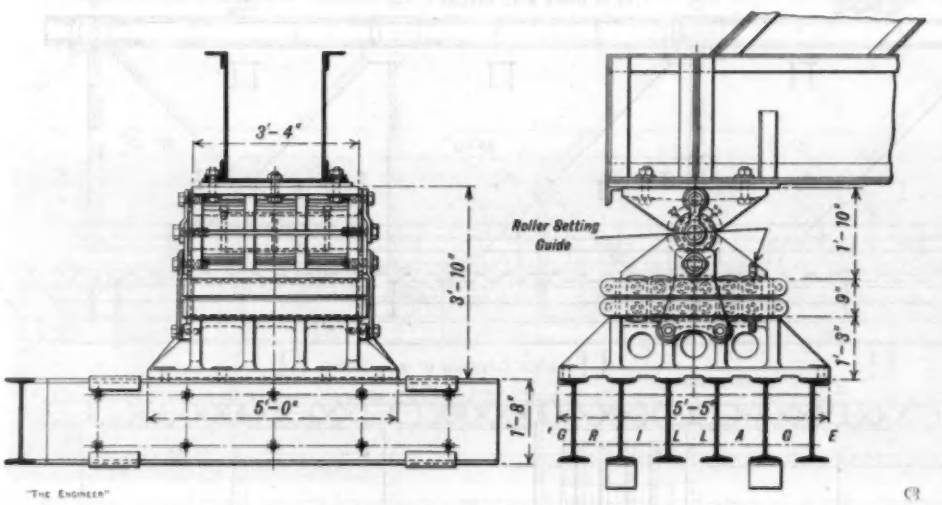


FIG. 19—DETAIL OF ROLLER BEARINGS

from the bed of the river itself, being collected in barges from banks above the bridge at times of low water. It was found suitable for use in the concrete without any further washing or screening. The whole of the cement used was sent out from this country. The steelwork was fabricated in Glasgow. Its total weight was about 8600 tons, of which the caissons accounted for 1630 tons.

The work of constructing the bridge was carried out under the general direction of the Crown Agents for the Colonies, acting on behalf of the Nigerian Government, and to the design and under the supervision of the consulting engineers, Messrs. Coode, Wilson, Mitchell, and Vaughan-Lee, with whom have been associated the firm of Mott, Hay and Anderson, of Westminster. The contractors for the whole of the work were Sir William Arrol and Co., Ltd., of Glasgow, and the time taken to bring the work to completion rather more than four years.

Flowing Water.

No. VI.*

IRRIGATION.

In the application of water to agriculture the first condition to be attained is that the waters spread over any surface shall be able to flow away easily, and not lodge in the lower portions, for, directly it becomes stagnant, it develops the growth of noxious plants. Hence it is necessary so to arrange the levels of the land to be irrigated as to attain the following conditions. First, the waters must arrive at the culminating point; secondly, they must be distributed over the lower portions falling away from these points, and thirdly, they must be collected in the outfall drains immediately they have passed over the land to be irrigated.

The different systems employed may be described, generally, as consisting of (i.) Irrigation by canals and feeders, which conduct the water to the land and distribute it over the surface; (ii.) irrigation by flooding; (iii.) irrigation by infiltration canals, and (iv.) irrigation for the purpose of retaining the matter in suspension in the water, which consists in allowing waters highly charged with sediment to flow over the land, and to "deposit tranquilly the matter they contain." This system is known by the name of "warping."

The epoch during which irrigation is most profitably employed depends to a certain extent upon the object it is desired to effect. In warm climates this is principally to develop the progress of vegetation by lowering the excessive heat of the soil and to obviate the inconvenience of drought. In colder climates water is often turned over meadows for the express purpose of protecting them from frost. In the case of warping, the water is turned on to the land at the season when the freshets bring down the greatest amount of sediment.

In this country the process of irrigation usually takes place after October, when the aftermath has been carried. The water is first kept on the ground for a fortnight or three weeks at a time. It is then let off and the ground left dry for five or six days. This process of alternate flooding and drying is continued until the end of January, care being taken to let the water off if a hard frost intervenes. As the spring advances, and the grains shoot forth, the periods of watering are shortened, so that the flooding shall not last more than four or five days consecutively. In the southern counties the meadows are ready for the reception of stock of all kinds in the middle of March; but in the north, when the grasses do not make such early progress, the flooding is generally continued throughout the whole month of May. Flooding during the summer months produces a rapid and rich vegetation; but it is by summer flooding, where it is practical, that the fatal disease of rot is introduced. It is important that the water be removed from the land as rapidly as possible after irrigation has terminated. This removal of surplus constitutes, in fact, the difference between water meadows and marshes.

In certain areas where the climate is hot and dry, and the soil of a light character, irrigation has been applied to gardens and pleasure grounds in all positions to which it could be conveyed. The Valley of Damascus and others situated at the base of snow-capped mountains are examples of where this system of irrigation is practised. The same general principle with respect to procuring water apply in this zone as in others, excepting that instead of being allowed to flow over the surface, as in the case of water meadows or rice fields, to be described later, it is confined in regular channels and produces its effect by infiltration through the light soil prevailing in those regions. Such a process of irrigation as above described can only be successfully carried out upon the banks of a running stream fed from a perennial source. The character of the husbandry of such districts naturally takes its principal characteristics from the circumstances in that meadow lands are rare while gardens and orchards are common.

Rice, or the paddy plant, is cultivated to a considerable extent in Southern Europe, Asia, Africa and America, below the 46th parallel of latitude. It is essentially an aquatic plant, and requires to be constantly immersed in order to perfect its development. It appears that the quality of land upon which it is raised is a matter of but little importance comparatively with that of the waters, and that the latter is by so much better as it is charged with the greater quantity of extraneous matter.

Whatever be the nature of the ground to be converted into rice fields, the first condition requisite is that the water be preserved continually in movement, and that all brought upon the land be removed. A series of plane surfaces must be formed, so that no part be allowed to remain dry, and that the water be not allowed to stagnate in any part. The whole area, therefore, must be levelled, and if it be too extensive for a single surface, it may be divided into several, provided each is horizontal. If the inclination of the ground be steep, it should be terraced. The land is divided by retaining banks, first longitudinal in the direction of the feeding channel; secondly, transverse across the direction of flow, so that when these banks are completed the rice plot is divided into a series of polygons or compartments. The size of these polygons

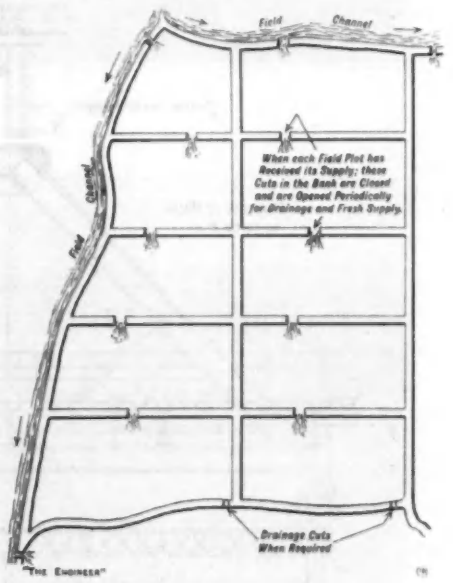

Field
Channel
When each Field Plot has Received its Supply; these Cuts in the Bank are Closed and are Opened Periodically for Drainage and Fresh Supply.
Field
Channel
Drainage Cuts When Required
"The Engineer"

FIG. 1

is principally regulated by the difference of levels of the planes of the respective parts of the rice plot. In those which have much inclination they are numerous, in order to economise the labour of disposing them in horizontal planes. The quantity of water available is another consideration; whilst it must be born in mind that the increased number of banks occupies a considerable surface of valuable land. It is usual to make the banks about 6in. above the ground on the upper side, and about 1ft., or more, on the lower. The width is never less than 6in. at the crown, but, as the top of the bank often serves for a path, as well as for the particular object of the formation, it may vary indefinitely. The banks are made with the earth taken from the fields during the process of planing.

When the banks are terminated as indicated in the diagram, Fig. 1, the water is let into the first division and allowed to rise to the required height all over the surface. Openings are then made in the lower banks and the water is successively let into all of them, so that the area becomes converted into a succession of

* No. V. appeared November 13th, 1931.

small ponds, separated by banks averaging 6in. in height. These preliminary indications serve also to verify the levels of the surface, all the portions left dry requiring to be lowered. During the whole life of the rice plant it is subject to irrigation by flooding in a manner varying with the degree of its maturity or the nature of the wind. It is therefore necessary to dispose the irrigation upon such principles as to be able to regulate the flow and to shut the supply off when so required by means of hatches or sluices. It is important that the supply be continuous and stagnation avoided. This removal of the water after it has performed its functions constitutes the difference between an irrigated rice field and a swamp or marsh. After the crop has been carried all the water is withdrawn and the land is left exposed to the action of the atmosphere throughout the winter months.

It does not enter into our province to describe all the methods of cultivating the paddy plant, which vary in different localities. There are numerous varieties of rice, and the period of a rice crop varies with the class of rice grown; the best in quality and outturn requires six months' irrigation from seedling to harvest, and is only grown under irrigation sources which have an assured supply. The more coarser and less valuable varieties can be matured in three months.

The deltas of the rivers, the Godavery and the Kistna, in South India, are composed of black alluvial soil, the washings of Central and Deccan India, the greater part of which area is covered with "black cotton soil," a fine black soil highly argillaceous and slightly calcareous. This soil does not extend to great depth in the Deccan Plains, where it usually alters into decomposed rock. The origin is attributed by some writers to the disintegration of volcanic or basaltic rock. Others affirm that it is due to the impregnation of certain argillaceous soils by organic matter, possibly derived from large and thick prehistoric forests. It overlies all formations and shows no signs of aqueous deposition.

In the two deltas the black alluvial deposit, on the other hand, extends to great depths; it still retains its typical colour, and owing to its argillaceous character it opens out into deep fissures on drying. In its baked and cracked condition it requires at first a large quantity of water to bring it to the consistency of puddle, owing to the great increase of its volume. When wetted the cracks are completely closed and the soil becomes practically impervious. Hence, after the irrigation period is over and when water that has been standing on the land to a depth of 4in. or 5in. for a period of about six months has been run off there is no subsoil water. Wells often sunk to great depths will contain no water unless they meet with a substratum of sand.

The alluvial matter brought down does not possess any great manurial value, but by constant deposition on the irrigated fields it renews the soil so completely that rice crops have been grown continuously on the two deltas since the inception of the two irrigation systems in 1850 without detriment to the soil. Moreover, in the sandy lands bordering the coast repeated applications of large volumes of water highly charged with sediment have in time washed out the saline matter and deposited the alluvial matter they contain, turning sandy soils impregnated with salts and unfit for any cultivation into rich rice-bearing lands.

METHOD OF CULTIVATION.

In the Godavery and Kistna deltas the paddy seedlings are raised in nurseries near ponds or some source of water; as soon as the early freshets in the rivers bring down water sufficient for agricultural purposes the seedlings are transplanted.

In the Godavery delta seedlings are raised in June and transplantation begins generally about the second half of June, when the early freshets of the river come down. There is always a great endeavour on the part of the ryots of the delta to get their transplantation completed before the end of August, as owing to the change in the winds any delay beyond that date affects the outturn of the crop. The transplantation season is generally from the second half of June to the same period in August, occupying generally sixty-one days, when the maximum demand is made on the canal supply. After that the crop requires periodic watering so as to maintain a depth of from 4in. to 5in. on the land, the last watering being given in November. The period of the classes of rice grown in the Godavery delta is about five and a-half months.

The ryots of the Northern Circars and of Orissa have a practice of draining their lands towards the end of September prior to the heavy rains that are expected in October; the reason being to kill certain insects and to allow air to penetrate the soil. Should the October rains fail or be late in arriving, and as the ground should not be allowed to dry to any great extent, there is a heavy demand for water, and considerable strain is placed on the canal system. October is the month in which the grain is being formed, chiefly from the material stored in the stalk and moisture must be present to flush the material from the stalk into the head or the grain will be shrunken. Thus water is required in the early stage of the growth of a paddy plant for the development of the stalk and in the latter part for the production of seed.

WATERINGS.

No subsequent watering of any crop requires so much water as the first given on fallow land to saturate it to the extent necessary for the required agricultural operations. Experiments have shown that in the case of the black alluvial soil described above, when the soil is dry and cracked it requires a quantity of water equivalent to a depth of 20in. on it to render it fit for ploughing and to produce the necessary depth for transplantation. After that a supply equivalent to 0·25in. a day is needed to make up the losses from transpiration and evaporation. The theoretical quantity of water for a paddy crop under these conditions may be found as follows:—

Let q be the supply in a canal during the transplantation season, n the supply required per acre to prepare the dry ground and to bring it to a state fit for transplantation, m the supply required per acre to maintain the crop after transplantation.

If a_1, a_2, a_3 . . . are the areas transplanted each day from the supply q in the canal,

$$a_1 = \frac{q}{n}$$

$$a_2 = \frac{q - a_1 m}{n} = a_1 \left(1 - \frac{m}{n}\right)$$

$$a_3 = \frac{q - a_1 m - a_2 m}{n} = a_1 \left(1 - \frac{m}{n}\right)^2$$

. . . . . .

$$a_x = a_1 \left(1 - \frac{m}{n}\right)^{x-1}$$

If A be the total area transplanted from a supply q in a period of x days,

$$A = a_1 + a_2 + a_3 \ldots a_x$$

$$= a_1 \times \frac{1 - \left(1 - \frac{m}{n}\right)^x}{\frac{m}{n}}$$

and $a_1 = \frac{q}{n}$

$$\therefore \; x = \frac{\log\left(1 - \frac{m\,A}{q}\right)}{\log\left(1 - \frac{m}{n}\right)}$$

x being the period in days in which a canal with a volume of q cusecs will supply sufficient water to transplant A acres. A supply of 20in. on the ground would be a supply of 23in. to 24in. at canal head. The percolation losses in the Godavery delta canals being very small. One cusec flowing for one day of twenty-four hours is equivalent to 23 to 24 acre-inches. Therefore a flow of 1 cusec a day should be sufficient, under the conditions described, to render 1 acre fit for transplantation ($=n$).

Under the same conditions, m is $\frac{1}{90}$ cusecs—nearly (0·25in. a day).

Substituting these values:

$$x = \frac{\log\left(1 - \frac{A}{90\,q}\right)}{\log\left(1 - \frac{1}{90}\right)}$$

$$\left(1 - \frac{1}{90}\right)^x = 1 - \frac{A}{90\,q}$$

or

$$q = \frac{A}{90\left\{1 - \left(\frac{89}{90}\right)^x\right\}}$$

$$\text{If } x = 61,\; q = \frac{A}{43}$$

Or for a base of sixty-one days the duty during the transplantation season will be 43.

In the case of the Godavery Western Delta irrigation system of 400,000 acres, the supply required at the canal head during the transplantation season to complete transplantation in sixty-one days would be:

$$\frac{400{,}000}{43} = \text{say, } 9300 \text{ cusecs.}$$

Hence unless the river supply is augmented by rainfall a very heavy strain is placed on the canal system.

The tables below give the working of the Godavery Western Delta main canal for the years 1907 and 1908. The discharges were obtained from gauge readings calibrated by current meter.

TABLE I.—1907.

Month.	No. of days.	Average discharge. Cusecs.	Mean rainfall over the area. Inches.	Remarks.
June	30	1781	15·69	Area irrigated 390,000 acres
July	31	4093	2·94	
August	31	4400	5·60	
September . .	30	5554	1·59	
October	31	4702	0·73	
November . .	20	4312	0·27	
	173	4135 mean	26·81	

The maximum demand occurred in September; the ryots drained their field, and the rain failing there was a sudden demand for water. The period of the crop seedtime to harvest was 173 days.

$$\text{Average duty } D = \frac{390{,}000}{4{,}135} = 94$$

Therefore the depth of water for maturing the full paddy crop was

$$\text{Irrigation, } \frac{2 \times 173}{94} = 3{\cdot}68\text{ft.}$$

$$\text{Rainfall, } \frac{26{\cdot}81}{12} = 2{\cdot}234\text{ft.}$$

Total, 5·914—say, 6ft.

During the transplantation period, July and August:—

Average supply, 4246 cusecs.

Duty, 91·8, say, D=92. Period, $x=62$.

∴ Depth on irrigated area due to irrigation

$$\frac{2 \times 62}{92} = 1{\cdot}35\text{ft.}$$

Rainfall, 8·54in. = 0·71ft.

Total depth during transplantation season, 2·06ft.

It is very probable that the heavy rains of June assisted transplantation to a considerable degree.

TABLE II.—1908.

Month.	No. of days.	Average discharge. Cusecs.	Mean rainfall over the area. Inches.	Remarks.
June	30	909	1·09	Area irrigated 380,000 acres
July	31	5612	5·41	
August	31	5901	9·69	
September . .	30	5255	12·95	
October	31	4532	4·65	
November . .	23	4702	0·05	
Total	173	4491 mean	33·84	

In 1908, as a result of the short supply in June, and the scant rainfall in that month, the area irrigated was 380,000 acres, or 10,000 acres less than in 1907. The duty at maximum demand was

$$\frac{380{,}000}{5901} = 64{\cdot}4.$$

Average duty in July and August = 66.

Depth during transplantation season

$$= \frac{2 \times 62}{66} = 1{\cdot}9\text{ft.}$$

Rainfall, 1·26ft.

Total depth during transplantation season = 3·16ft.

The average duty $= \frac{380{,}000}{4491} = 84{\cdot}9$, say, 85.

Depth on the irrigated area due to irrigation alone

$$= \frac{2 \times 176}{85} = 4{\cdot}14\text{ft.}$$

Depth on the area due to rainfall = 2·82ft.

Total depth during period of cultivation was therefore 6·96ft. A good deal of the rainfall of September must have been surplused.

The data given in Tables I. and II. convey a general idea of the water requirements of a paddy crop as grown under the Godavery Delta irrigation system. No account is taken of the amount that may have passed through surplus escapes. In order to arrive at a more accurate estimate of the crop requirements during the transplantation season, further observations were carried out. Table III. shows the discharges of the Godavery Western Delta main canal during the transplantation season of 1914.

The discharges are arrived at after deducting surplus discharges at escapes and terminal weirs, from the discharges compiled at the head of the main canal.

The total area irrigated was 400,000 acres. The discharges are the average for the half month.

TABLE III.

1914, month.	Period.	Discharge. Cusecs.	Rainfall on the area. Inches.	Remarks.
June	1 to 15	1767	1·60	Area irrigated. 400,000 acres
June	15 to 30	3560	1·15	
July	1 to 15	5754	1·33	
July	16 to 31	3577	7·05	
August	1 to 15	2268	6·58	
August	16 to 31	1618	2·69	

As the supply in the first half of June was small, transplantation did not actually begin until the middle of that month, though small areas may have been transplanted in the early part of June. The transplantation was completed by the middle of August. The greatest demand was in the first half of July, when transplantation was in full swing. The duty or area irrigated per cusec of flow for the whole area for the period being $\frac{400{,}000}{5754}$, or nearly 70.

The rainfall in the latter half of July reduced the demand for canal water in August. During the transplantation season, June 16th to August 15th, or sixty-one days, the rainfall on the area was 16·11in. = 1·342ft.

Depth on area during the period due to irrigation = 1·155ft.

Total depth on area during the transplantation season = 2·497, say, 2·5ft.

The supply during the first half of June cannot be

taken into consideration as the canals of the Godavery Delta irrigation system are open for navigation as soon as the early freshets come down the river. The importance of assistance from rainfall during the transplantation season is obvious.

In the Kistna Delta irrigation system the irrigation season is later in the year. The seedlings are raised about the middle of June, transplantation begins about July 5th, is at a maximum in August, and should be completed by September 15th or the outturn will suffer.

A single paddy crop with careful regulation requires 66 acre-inches at the head of the delta, including rainfall—period of crop 163 days. In the Kistna Western Delta system the average for the three years 1907–09 during the transplantation season indicated that the transplantation period was sixty-two days, and the depth on irrigated area during that period 2·08ft., including rainfall.

The statement below compares outturn of crop in the same year for soils under the Kistna Western Delta irrigation systems :—

(1) Lands under channel irrigating black alluvial soil ; experimental acre ; 2638 lb. grain. Supply, irrigation+rainfall, 58·30in.

(2) Lands under channel irrigating what was originally poor sandy soil, but is now covered with deposits of Kistna River alluvial matter. Yield per acre, 2239 lb. grain ; water consumed, irrigation+rainfall, 64·26in.

(3) Lands under channel irrigating poor sandy saline soil under process of being reclaimed ; 936 lb. grain, copiously watered.

Proceeding southwards, the irrigation season becomes later, depending on the monsoons or periodic rains. The south-west monsoon current sets in during the first fortnight of June on the Bombay and Bengal coast. On the West, or Bombay Coast, it blows almost directly athwart the coastline and discharges an enormous amount of rain on the face of the Western Ghats. In the Bay of Bengal it blows from the south-west and, passing by the Coromandal Coast, and the Carnatic to which it furnishes an occasional shower, crosses the coastline to the north of the Kistna River. Between Masulapatam and Orissa, the rainfall is rather greater, but it is not until it reaches the shores of Bengal that it pours in volume into the country. On the face of the Western Ghats the rainfall is excessive, but beyond on the Deccan tableland, it rapidly diminishes to less than one-sixth of the average fall on the West Coast. On the Mysore and Bellary tablelands and on the plains of the Carnatic, the fall is scanty from June to early October. To the north of the Kistna River the rainfall is more frequent. In September the force of the monsoon begins to decline, and after the middle of the month it ceases to carry rain to the greater part of North-West India. In the west of the Bay of Bengal, the monsoon begins to recur in October, and a copious rainfall, known as the North-East monsoon, is discharged on the plains of the Carnatic. October is, of all others, the month of seven cyclonic storms in the Bay of Bengal. The rains of the Carnatic last till December, the seat of their chief prevalence moving gradually southwards to Ceylon with the declining year.

In the Cauvery delta under the Cauvery and Vennar irrigation channels (*vide* "Flowing Water," IV., THE ENGINEER, July 3rd, 1931), comprising an area of 1,000,000 acres, where paddy cultivation has been practised for centuries, the traditional rule is for seedlings to remain in bed for one quarter of the period of the crop ; the seedlings of the chief class of paddy grown in the delta—there are ten varieties of paddy which are cultivated in the South of the Madras Presidency—are generally put down about July 15th ; transplantation begins about August 20th, and should be completed about October 1st. The crops are harvested early in January. Proceeding farther south the season for cultivation gets later.

The critical period in the cultivation of paddy as practised in South India, is the transplantation season. The season is usually fixed by one or the other of the two monsoons in order to make use of the actual rainfall on the irrigated area.

Where the rainfall exceeds 50in. and is more or less equally divided between the monsoons, and the soil is of such a character as not to require an excessive amount of water for initial agricultural operations the ryots of Orissa in Bengal, and in the Ganjam District of the Madras Presidency, have for centuries been accustomed to mature rice crops entirely from local rainfall, a small extent of the crops being supplied from small tanks in which the local rainfall is impounded. In good years of rainfall the crops do well, but in bad years they fail.

It may be generally stated that except in arid areas the soil some feet below the surface is never dry, the quantity of water present in it depending, among other things, on its nature. Provided the soil is uniform, during the dry weather there will be found, commencing from the surface, an increased quantity of water in each succeeding stratum. The rate at which water leaves the soil depends on a law similar to that which governs the loss of heat, and depends on the amount of water in the soil. The loss of water will also depend on the number and size of the capillary spaces. Capillary water moves from a wet soil to a dry one, and so causes it to spread laterally and to rise from the wetter sub-soil to the surface. The water will rise to a greater height in a firm-textured than in a coarse-textured soil, but will rise more quickly in the latter. This explains why a crop will wither even when the soil below root range still contains abundant water, as the latter cannot move up fast enough to meet the plants' requirements. Also, why a crop will mature in some soils with limited assistance from rain or irrigation, whereas, in other soils, it will require constant irrigation. In the sandy soils of the Nellore and the Chingleput districts of the Madras Presidency, which receive little rain from the early period of the South-West monsoon as described above, a class of paddy is grown, under tanks or small reservoirs, which, in its early stages of growth, depends on the water stored in the soil, and the rate at which it can supply the crop root. The period of the crop is 4½ or 5 months ; the initial process of tilling, preparing the land, and sowing—the seed is sown broadcast and not transplanted—requires 2in. of rainfall in July to August. The agricultural operations are not begun until there has been this sufficient rainfall. The slight rains of September, and the water of the soil, are sufficient to keep up the young plant. In October the North-East monsoon rains fill the tanks, and a regular supply of artificial irrigation is given to assist the rainfall in maturing the crop, which is reaped before January 15th. It is obvious that this class of cultivation cannot be carried out in a clay soil.

In North India the main crop is wheat, and the amount of irrigation necessary depends on the rainfall and the nature of the soil. The crop is a cold-weather one, and is sown in the beginning of November, after the South-West monsoon rains are over, and harvested in March. Little water is taken until the crop is a month old, the maximum demand for water occurring from the middle of February to the end of March. The diagram, Fig. 2, gives the theoretical

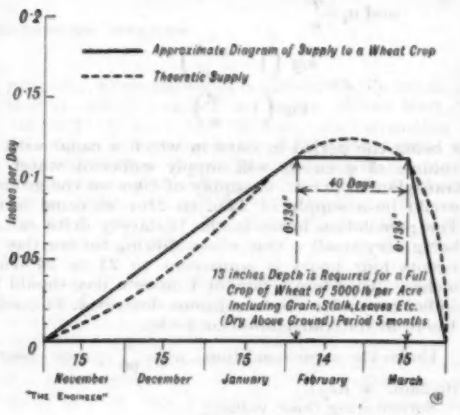


FIG. 2

supply for a full five-month wheat crop ("Memoirs of the Department of Agriculture in India"). Some soils in the Gangetic Alluvium, after the rains, have ceased, hold sufficient water to enable a heavy cold-weather crop, such as wheat, to be grown without further assistance from rainfall, or irrigation. Other soils, owing to their argillaceous character, although containing abundant water, cannot supply it to the secondary root of the cereal at a rate sufficient to prevent the moisture content of the soil being lowered to the wilting point. Irrigation in such areas should be applied at sufficiently frequent intervals to maintain the moisture content at what may be termed the optimum condition—that is, when the pore spaces of the soil contain sufficient capillary water to cover the crop roots and also a certain percentage of air—as air as well as water is necessary—for the best growing condition of the crop.

Under field conditions the soil next to the ground water plane, or water-table, will be saturated, and the moisture content will decrease above that point in proportion to the distance from the water-table. When the water-table is far from the surface, and the rainfall is scanty, arid conditions obtain. In the Panjab the soil is composed of deep alluvial material, more or less of a porous nature overlying fine sand, which extends to great depths. The water-table before irrigation was introduced was from 60ft. to 80ft. below the surface of the ground. The rainfall is scanty, the average being 12in. a year, the greater part being precipitated during the summer months, July to September, and the winter months, October to March, receiving but 2in. Arid conditions, therefore, prevail, and irrigation for the development of plant growth becomes a necessity. The application of irrigation in the Panjab to lands which were interminable waste, with scarcely any living beings on them, has converted them into veritable gardens producing wheat, rice, sugar cane, cotton, maize, millets, &c., the soil being naturally fertile and needing but water to produce results comparable to those of a gold mine.

In the Panjab there are two distinct agricultural seasons and two annual crops. The first comprises the six summer months, April to September, when the melting Himalaya snows, together with the summer rainfall on the area, afford abundant supplies for the "Kharif" or summer crop. The second season comprises the six cold months, October to March, and is the season for the "Rabi" or winter crop. The winter discharges of the Panjab rivers are small compared with the summer flow, but the agricultural conditions are such that fairly long intervals can be permitted between waterings given to the crops in the "Rabi" season, so that although the capacity of a main or conducting canal may be greater than the winter flow of its parent river, this flow is distributed in turn to the various branches.

The chief crop grown in the Panjab is wheat, which is a cold weather or "Rabi" crop. For its economic beneficial use there is a total depth of water which will give a maximum yield, and any quantity in excess is wasted. As already stated, the soil of the Panjab is of a porous character ; hence small depths of water applied for irrigation will have no detrimental effect on it while excessive depths may raise the subsoil level of saturation to an extent detrimental to the public health.

The effect of the length of run of the water in flooding a field plot or compartment has in such soils to be considered. If the run be of any great length the upper end of the field plot or compartment is likely to receive a large excess of irrigation water, which is lost by deep percolation and may not reach the lower end of the plot. Experiment has shown that a greater head or rate of flow covers a field more quickly and less irrigation water is used ; decreasing the head or rate of flow causes a proportionately larger increase in the time necessary to obtain complete irrigation, and requires a greater depth of irrigation water per acre irrigated and a greater loss by deep percolation. Mr. Kennedy, from experiments made, found that what may be termed the optimum area of a field plot to be 70ft. by 70ft., and the best number and depth of watering for a wheat crop to be four waterings during the season of from 3in. to 3½in. in depth—Panjab Irrigation Paper No. 10. In virgin soil the outturn is increased by a fifth watering—Panjab Irrigation Branch Paper No. 11. The actual depths of water in feet used on the area irrigated by the Chenab Canal in 1900 and in 1920 are :—In 1900, Kharif, 3·83ft.; Rabi, 1·65ft. In 1920, Kharif, 2·08ft.; Rabi, 1·4ft.—"Panjab Irrigation," W. P. Thompson, 1926.

Colonel Baird Smith, writing in 1856, states :—There is one point of view from whence the periodic famines which in past years desolated different parts of India may be looked at with satisfaction. They have been the precursors of all those works which have marked the progress of public improvement for agricultural objects. To the famine of 1837–38, followed by the harrowing distress of the districts between the Ganges and the Jumna rivers, we owe the magnificent project of the Ganges Canal. To a like visitation in 1833 in South India in the districts of Rajahmundry, Masulipatam, and Guntur, bordering on the Godavery and the Kistna rivers, when not fewer than 200,000 people perished either from hunger or pestilence, South India is indebted for the extensive works of the Godavery and the Kistna irrigation systems. "These two works are a testimony to our national character in the scale of their construction, and in their influence on the material prosperity of the country they are of the greatest—"Irrigation in South India"

Recurring famines in the Panjab, due chiefly to a population which pressed too heavily upon the land for subsistence, lack of rainfall, and want of transport facilities, led the British Government to launch upon an extensive development of canal irrigation during the first years of British occupation of the Panjab. The Bare Doak Canal was projected and constructed before 1858. Since then the advances made in the construction of irrigation works by the Government of India have been great. The more important are the Periya irrigation project—"Proc.," Inst. of Civil Engineers, Vol. CXXVIII.—the Rushkullia irrigation project and the Cauvery dam project—all these projects involve storage reservoirs—in South India. The Mahanaddi irrigation system in Orissa. In the Panjab the Chenab canal system, irrigating over two million acres—"Proc.," Inst. C.E., Vol. CLIII.—and the Panjab triple canal project, irrigating an equal area—"Proc.," Inst. C.E., Vol. CCI. "By means of this rather complicated engineering feat an area which was once the most desolate portion of the Panjab has been converted into one of that province's chief cotton and wheat-producing areas."

In our present time there are the Sarda Canal project in the United Provinces, commanding several million acres ; and the great barrage in Sind, the Lloyd Barrage across the river Indus below the Sukkur Gorge, destined to irrigate 5 million acres.

In 1856 there were 3 million acres irrigated under Government irrigation works in India, in 1880 there were 10 million acres, in 1900 this area had increased to 20 million acres. In the Fashi or agricultural year 1923–24 the area under Government irrigation works in India amounted to 26,538,000 acres, the estimated value of the crops on the area irrigated being 14,000 lakhs of rupees—a lakh of rupees equals £7000.

The new schemes when developed will eventually bring the total area under irrigation from Government irrigation works to nearly 40 million acres.

Apart from the profitable returns, when we contemplate the prevention of famine and the preservation of the lives of the people of India, the irrigation works of that country are a testimony to the benefits conferred on India by British rule.

Institution of Electrical Engineers.

No. I.

SUMMER MEETING.

WITH an attendance of about 150 members and ladies, the Institution of Electrical Engineers began its summer meeting on Monday last at Harrogate, where the party assembled in the evening at the Grand Hotel. Invitations were extended by the Corporation to the visitors to attend concerts and to take part in games, while the special baths for which Harrogate is, of course, noted could be taken at reduced fees. Besides the official programme of visits members were invited to pay informal visits to the works of E. Green and Son, Ltd., Wakefield; J. Blakeborough and Sons, Ltd., Brighouse; the English Electric Company's Phœnix Works, Bradford; and to the Yorkshire Copper Company's works, Leeds.

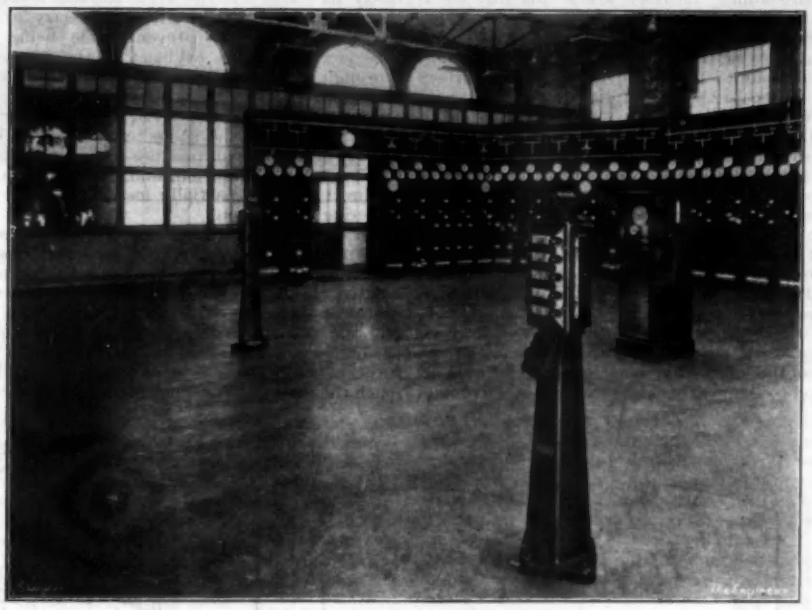


FIG. 1—CONTROL ROOM IN KIRKSTALL POWER STATION

On Tuesday morning the party left Harrogate for Leeds to see the Kirkstall power station and the "grid" sub-station of the Central Electricity Board, and at the conclusion of these visits it divided into two groups. One returned to Harrogate, and after taking luncheon at the Grand Hotel visited Fountains Abbey, whilst the other section journeyed by coach to Huddersfield, where luncheon was provided by Hopkinsons, Ltd., whose Britannia Works were subsequently inspected. The journey to Fountains Abbey was made through Ripley and thence to the West Lodge of the Abbey. The visitors walked through the grounds, passing Fountains Hall—built in 1597 from stone obtained from the ruins of the Abbey—to the Cistercian Abbey, the building of which dates from the early years of the twelfth century.

The Kirkstall power station of the City of Leeds Electricity Department was opened on July 6th of last year, and is therefore thoroughly modern. Its present capacity is 50,000 kW and all its boilers are fired with pulverised coal. For the greater part of the year ample supplies of cooling water are available from the river Aire, and in the event of the works being extended and the capabilities of the river being overtaxed, cooling towers will be provided to work in conjunction with the normal water supply. Pulverised coal firing was adopted at Kirkstall mainly on the ground that it permits very large-capacity boilers to be employed, which can operate over a wide range of output with consistently good efficiency, whilst the central system was chosen because of its security and the possibility of dealing with all grades of fuel by the installation of mechanical drying plant. Another matter which influenced the decision was the comparative ease with which a scheme of coal carbonisation could be added should such a scheme become available.

The turbine plant, which at present consists of two 25,000-kW sets, is designed to operate at a pressure of 450 lb. per square inch and a total temperature of 750 deg. Fah. To meet these conditions the three tri-drum Stirling boilers—each capable of evaporating 160,000 lb. of water per hour—are designed to work at 475 lb. per square inch. The overload capacity is 184,000 lb. per hour. All the boilers are fitted with superheaters, economisers, and air heaters, and two Davidson dust collectors are provided for each unit. The ash handling plant is a "Hydrojet," as installed at the new Ironbridge station and in various other stations of modern design.

The turbo-generators, which were built by the British Thomson-Houston Company, will develop 25,000 kW at 70 per cent. power factor. Each turbine has two cylinders, that for the high pressure being of the pure impulse type with sixteen stages, whilst the low-pressure cylinder is of the double flow type and is fitted with reaction blading throughout. W. H. Allen, Sons and Co., Ltd., supplied the condensing plant, which is of the vertical regenerative type with the condensate outlet arranged on the steam inlet side to ensure that the condensate temperature corresponds with that of the exhaust steam from the turbine.

It is only natural that, being one of the earliest undertakings distributing alternating current, the plant of the Leeds Corporation Electricity Department has materially changed since the supply was first established. Originally single-phase 83-cycle current was generated at a pressure of 2000 volts, and small transformers were installed on the consumers' premises. To-day, however, three-phase current is generated at the standard frequency and at a pressure of 11,000 volts, and, needless to say, the "house-to-house" system has been abolished. The continued policy of the Electricity Committee to lay mains, not only to meet the requirements of the time, but also to cater for future demands, has provided the city of Leeds with a very comprehensive distribution system. The fact that more than 100,000 consumers are supplied from the undertaking's mains indicates the important part which electricity plays in the life of the city. Taking the population of the area of supply at 480,000, the consumption, including that required for traction purposes, was very nearly 350 units per head in 1931.

The visit to the Britannia Works of Hopkinsons, Ltd., at Huddersfield, proved highly interesting and instructive. Although we dealt fully with these works in our issues of August 18th and 25th of 1930, no apology is needed for calling attention to some of the latest developments. One of the most recent additions to the works is a 2000 lb. pressure boiler for testing purposes; another is a high-frequency electric furnace in the "Platnam" foundry, which is also equipped with moulding machines and appliances for the centrifugal casting of valve seats and sand blast and dust extraction plants. As many engineers are aware, "Platnam" was originally developed by the firm in 1903 and has gained a reputation as a hard, non-corrodible, and non-erodible metal for withstanding the scoring of gases and fluids at high velocity and high temperature. The firm claims that there is no metal or alloy superior to it for use under the severe conditions to which the head and seat of high-pressure and high-temperature steam valves are subjected.

For some years past the company has devoted attention to the subject of high-temperature research and the investigation of materials for construction. In this connection an experimental foundry containing a Booth direct arc electric furnace co-operates with the metallurgical laboratory in connection with the suitability of materials for high pressures and temperatures, and as one result of the investigations the company has introduced several alloys to meet the new conditions in steam practice. The metallurgical laboratory is equipped with several interesting appliances, including electric muffle furnaces, electrolytical benches, combustion benches, a balance room, and a metallurgical microscopic camera. The physical test house is equipped with a limit creep testing machine, a pyramid diamond hardness testing machine, a Brinell hardness tester, an Izod impact testing machine, and a Buckton 30-ton tensile and bend testing machine. Physical tests and microscopic photographs are taken of each cast before and after heat treatment, and the results are carefully recorded and preserved in a manner which ensures that the fullest particulars are available at any time. The company has devoted considerable attention to the subject of creep of materials at elevated temperatures.

Much information on the equipment of the works, methods of manufacture, and the company's products will be found in the two articles to which we have alluded, and it must suffice to call attention to one or two products we have not hitherto described. To meet the demand for a compact and reliable panel type engine-room telegraph capable of transmitting communications between the control room and engine-room of a power station, the firm has introduced the type of apparatus illustrated in Fig. 1, which is a general view of the control room at the Kirkstall power station. The principal feature of the apparatus is that it is instantaneous in action and enables the attendant to keep his attention on the switchboard instruments of the machine about to be started up or shut down whilst he is giving signals. The instrument is suitable for synchronising purposes where the system of governor control from the control room is not adopted or is temporarily out of use. The transmitting instrument shown on the right in Fig. 1 is provided with a push button alongside each signal panel and also one below the set of panels, for calling the attention of the attendant in the engine-room. The arrangement at the top of the apparatus is a buzzer, which indicates to the control-room attendant that his order has been complied with. The receiving instrument shown on the left in Fig. 1 is similar to the transmitting instrument, except that there are no push buttons or buzzer. The instruments are made for working with A.C. or D.C. and all the accessories are designed to operate at the same voltage.

The visitors were afforded an opportunity of inspecting some of the electrically operated valves that are being made for some of the new power stations that are being erected. Various types of control stations are supplied for use with these valves, and Fig. 2 shows a three push button emergency control station with indicator lamps and "break-the-glass" feature to protect the push buttons from accidental operation.

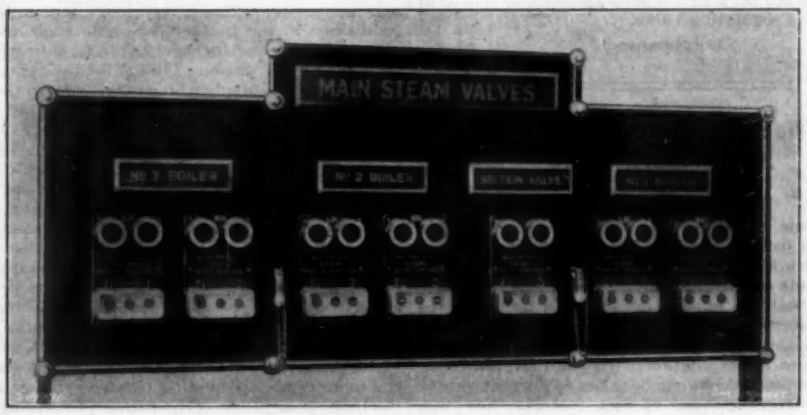


FIG. 2—VALVE CONTROL BOARD IN KIRKSTALL POWER STATION

A new water gauge designed to give a clear view of the water level in a high-pressure boiler from the firing floor level is shown in Fig. 3. The gauge consists of a cast steel body and beam encasing a heavy section prismatic glass which provides a full 12in. sight. The glass presents a plain flat face to the water and steam, its prismatic face being out of contact with both, a matter which the makers claim to be of considerable importance, as they have found that any gauge glass which presents a prismatic face to the steam and water gradually becomes opaque. The gauge is illuminated by a strip type lamp and is constructed so that the contrast between the steam and water stands out clearly, the former acquiring a silver appearance and the latter a dull black. Two of these gauges have been fitted on the 2000 lb.

pressure test boiler and the water level is clearly visible at a distance of 120ft.

Another product inspected was the Hopkinsons' pressure feed lubricator, which is designed for regular lubrication under pressure of a number of lubricating points at varying levels, and for the accurate control, together with regulation, of the supply to the points. The lubricator consists of a cast iron housing which is constructed to form a reservoir and a pressure chamber. A perforated distribution plate is fitted to the latter, and a detachable plunger pump, which is provided with non-return suction and delivery valves, is operated by an excentric on the driving shaft. The lubricator is fitted with a small belt pulley or gear to suit the drive required, and is made in two sizes for 12-point and 32-point. The pump sucks in the oil from the reservoir and delivers it under pressure into the pressure chamber, wherein a flat-face disc revolves. This disc is driven by a worm which is formed integral with the driving shaft. The flat-face disc is held in position by a light coil spring when not under pressure, whilst when pressure is applied it

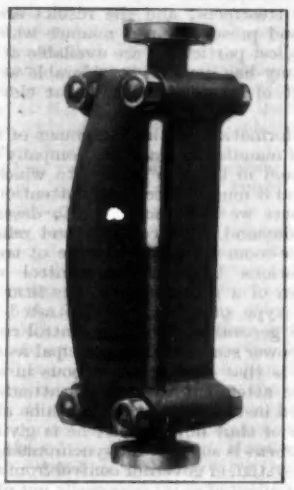


FIG. 3—HIGH-PRESSURE WATER GAUGE

makes a fluid-tight joint with the distribution plate, sealing the holes therein. A shallow groove is provided across the flat face of this disc, and as a consequence of its rotation the outlet holes are momentarily uncovered and a supply of lubricant is delivered from each. The pressure in the pressure chamber is registered by a dial indicator and is easily regulated by means of a pressure regulating valve which permits of surplus oil flowing back into the reservoir if the indicating pressure is exceeded. The lubricator is usually operated at a pressure of 40 lb. per square inch in the pressure chamber, and the amount of oil delivered to any or all the points can be varied from one drop per hour to the maximum of 0·8 cubic inch per revolution, by simply adjusting the delivery regulating valve, which is attached to the actual point of lubrication. An increased supply to meet some temporary measure can be obtained by raising the pressure in the pressure chamber, which is accomplished by means of the pressure regulating valve.

(To be continued.)

The Effect of Furnace Design on Scale Formation.

By H. C. ARMSTRONG, M. Inst. C.E., F. Inst. F.

ALL steels are subject to the formation of scale by surface oxidation when being heated for forging or other working, special consideration being given to this point in the manufacture of high-class steels in order both to ensure minimum scaling and to prevent decarbonisation. A certain amount of scaling is unavoidable if the furnace gases are allowed to come into direct contact with the material being heated, but precautions can be taken to prevent serious damage. Over-emphasis of such features, however, introduces an element of waste through imperfect combustion, to which attention is directed in the following lines.

The practical worker demands a furnace atmosphere which, if not definitely non-scaling, is, or can be readily made, sufficiently harmless to prevent damage which cannot be repaired by subsequent treatment. The usual method of obtaining the required reducing conditions is to supply an excess of combustible matter in the flame so that the "neutralising" of the active oxygen shall be done through the carbon in the flame and not by the material or the carbon contained in it. It has not so far been found possible to obtain the required inactive atmosphere when burning air and any fuel in theoretical proportions. Divergence from theoretical proportion causes heat loss, the loss from unconsumed or partially consumed gases being specially wasteful.

In the opinion of the writer, furnace designers have failed to appreciate the most important factor of the effect of thorough mixing of the furnace gases. It is this which entirely governs the conditions in close proximity to the material being heated. The more complete the intermixture between the gases which have been shown to be inocuous and the active oxygen, the less harmful is the latter. The writer is convinced that perfect mixing makes scaling, if not impossible, very nearly so, and that if furnaces were designed with this object kept well to the front, fuel consumption would be lowered, smoke emission lessened, and considerable economy gained. Not only would there be little necessity for the furnaceman to keep a "smoky atmosphere," but as experience has shown even appreciable amounts of excess oxygen can be present without causing undue harm if the mixing is very good. If the mixing is sufficiently thorough, the active and harmful oxygen is split up into minute portions which can only be in contact with the hot material for a fraction of time, and which are followed and quickly swept away by the other gases which do not form scale. If the mixing, on the other hand, is indifferent, the metallic surface may be exposed to the action of the humid oxygen, &c., for considerable periods, although in another part of the furnace the gases—unfortunately not in contact—may be preponderatingly reducing.

The writer would suggest that it is the degree of completeness of intermixture of the fuel gases and the combustion air which is the governing factor in scale formation in furnaces rather than the mass effect of a certain definite air/gas ratio, and that it is of the greatest importance that only fully mixed gases be allowed to reach the heated material, although these gases need not necessarily be the final products of combustion. Since all combustion takes place on the surface of the burning bodies, intimate molecular contact has the effect of increasing the speed of combustion and consequently close mixing aids conversion of the oxygen. Owing to the fact that combustion is rarely complete in the furnace, intermixture before and after burning are equally essential.

The furnace designer should, therefore, postulate that mixing of the furnace gases in the chamber should be as complete as circumstances permit.

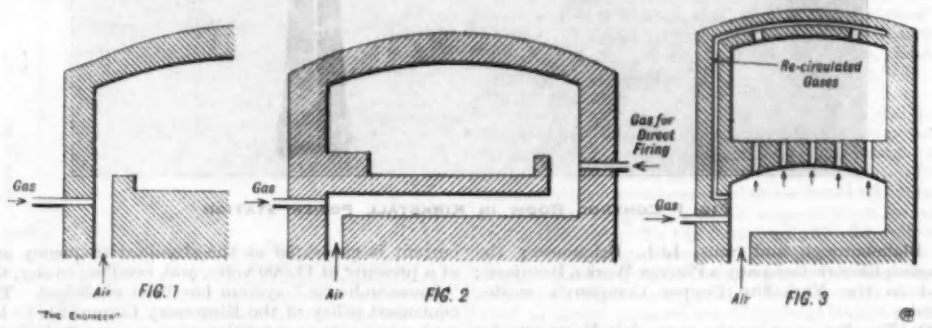
Too much notice has been taken of analyses of the waste gases leaving the furnace, which can be most misleading, and which even if there be no leakage of air into the furnace or flues through door openings and damper slots, &c., rarely give a true indication of conditions in the furnace. Nor do such analyses of gases taken in the furnace give any indication of the position of the various "ingredients" of the flame or the degree of mixing which takes place in the heating chamber itself.

The increased use of town and coke oven gas in metallurgical furnaces is drawing particular attention to the question of scale formation at high temperatures. Slightly over 4½ volumes of air are required for perfect combustion, so that the danger of the active air not being adequately mixed is much greater than with other fuels. The latter, coupled with the fact that a very small change in the quantity of gas supplied without a proportional change in the air, entirely upsets the ratio, may be largely responsible for the belief that this gas is detrimental to steel. Gas burner design varies immensely with very varying degrees of turbulence, but close study shows that the more crude the mixing between the air and fuel, the more susceptible is the furnace to scaling without considerable excess of gas. There is considerable room for improvement in most of the furnaces now operating, the size of which has a considerable influence on the matter. The smaller the furnace, the greater the necessity for thorough mixing.

Practical results from a number of small gas-fired furnaces, heating all classes of steel—including alloys—up to 1250 deg. Cent., illustrated very clearly how essential to a small furnace is a well-mixed short flame. With a furnace such as that shown in Fig. 1, it was found that, although working with an atmosphere much nearer theoretical showed definite fuel economy, it was necessary to carry a heavy reducing atmosphere to avoid excessive scale formation. The arrangement of the ports—common to many gas-fired furnaces—does not permit of anything but the crudest mixing. The gas stream is impelled into the air stream, but only just before the point of entry to the heating chamber, and the mixing of the air and gas is comparatively poor, the gases leaving the chamber before the combustion is completed. The furnace designers have been content with the gas and air streams at right angles to each other, but the scaling results mentioned, and the fact that "flame" leaves the furnace, show that the mixing arrangement is not carried far enough in this design to obtain non-scaling conditions with an economic fuel proportion.

Another group of furnaces—see Fig. 2—operated on the underfired principle, so that the burning air and gas has a considerable distance to travel through the channels under the furnace bottom could be worked successfully with only a very slightly reducing flame. Analysis of the gases at the point of exit from the furnace on occasions even showed a slight trace of oxygen. The gases whilst burning in the channels have full opportunity to mix, and when they arrive in the furnace chamber are consequently comparatively harmless. If the same furnace is worked on the direct-fired principle, it is necessary to increase the gas/air ratio to prevent scale being formed. This is very definite evidence of the importance of thorough mixing, since under the two conditions—direct firing and under-firing—different gas/air ratios are necessary for the same furnace, although on the same job and at the same temperature. The conditions of indifferent mixture are much more liable to permit scale formation, and the saving in gas due to direct firing is partially lost in the need of overpowering the oxygen.

An even more striking example of the benefit of good mixing is that of a special patented furnace—see Fig. 3—in which part of the waste gases are recirculated through the combustion chamber, with the object of obtaining evenness of temperature throughout the furnace without excessive heating in the preliminary combustion zone. Although in this furnace combustion is completed before the gases reach the material, it cannot in any sense be compared with the short flame burner type. Analyses of gases in the heating chamber showed up to 7 per cent. oxygen without undue scaling to the most susceptible material at temperatures between 1150 deg. and 1200 deg. Cent. The gases in this furnace must be considered to be almost perfectly mixed. There can be no other explanation for the absence of harm with such an extremely high excess of oxygen.



GAS AND AIR ADMISSION OF VARIOUS FURNACE DESIGNS

German furnace engineers have recently developed the short flame burner, in which the principle of high-pressure gas, inducing the required air, causes a very short flame, indicating the most efficient intermixture.

The British Selas system employs a somewhat similar burner, but a portion of the air is premixed with the gas by mechanical means. The remaining air is induced at the burner, the whole of the gas and air entering the furnace in a state of close intermixture. In the writer's experience, heating high-speed tool steel at 1250 deg. Cent. in close contact with the flame has not caused exceptional oxidation.

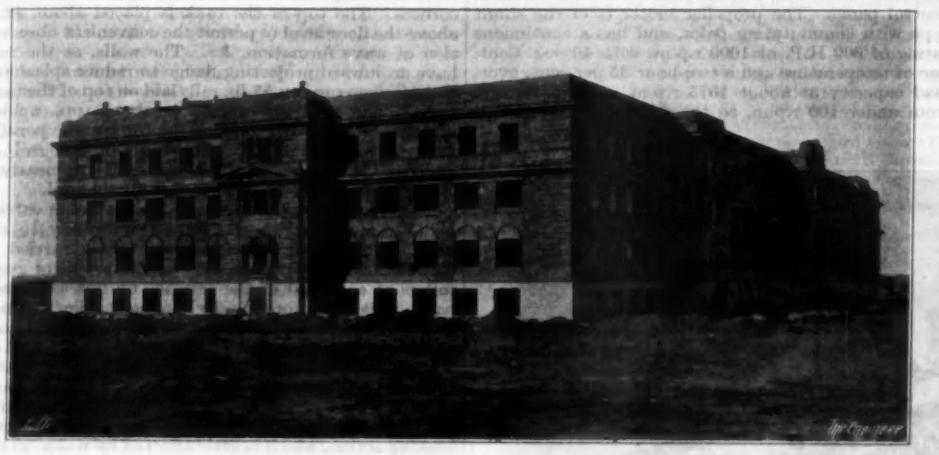
Many other examples of furnaces could be cited to illustrate the importance of intermixture and its bearing on scale prevention with economic fuel consumption. Although the foregoing has been taken for town gas, the same laws of mixing apply to furnaces fired with other fuels. Whatever the conditions, maximum fuel economy must be aimed at, nor should the high value of the special steels manufactured to meet the demands of modern engineering be accepted as the excuse for inefficient thermal performance through imperfect furnace design.

SYDNEY HARBOUR BRIDGE.

THE seven articles describing the design, construction, and erection of Sydney Harbour Bridge, which appeared in our issues dated from March 18th to April 29th, have now been reprinted in book form. Copies of this book, price 2s. 6d., plus 3d. postage, may be obtained from the Manager, THE ENGINEER, 28, Essex-street, Strand, London, W.C. 2.

IT is announced that according to the second Five-Year Plan of Soviet Russia, 30,000 kiloms. of new railway line is to be constructed and a similar length electrified.

NATIONAL RESEARCH LABORATORIES, OTTAWA



New Canadian Research Laboratories.

THE recent completion of the new building in Ottawa, Canada, at a cost in excess of 3,000,000 dollars to house the National Research Laboratories marks the beginning of a considerable expansion of the Council's activities. At present the National Research Council has gathered in Ottawa a professional and administrative staff of 119, and it enjoys the assistance, voluntarily and freely given, of more than 300 scientific men and representatives of industry in various parts of the Dominion who serve on the Council's Associate Committees. In addition, under the Council's Assisted Researches programme, 100 skilled investigators and assistants in the university and other laboratories of the country have been set to work on special problems of scientific or industrial importance.

Through the associate committees of the Council all the agencies and organisations concerned with many of the nation's major problems, such as grain rust, weed control, wool production, wastage of natural gas, asbestos, coal classification and analysis, engineering standards, aeronautics, electrical measuring instruments and testing are brought together, and their efforts co-ordinated and stimulated. Approximately one-half of the staff of the National Research Laboratories are of professional rank. Twenty-five of them possess a Doctorate Degree in Chemistry, Physics, or Biology.

Briefly, the purpose of the National Research Council is three-fold:—(1) To conduct researches to promote the use of the natural resources of Canada and to improve the technical processes in use in her industries, while developing processes which may induce the development of new industries; (2) to assist and direct similar researches carried on in other laboratories, either industrial or at Canadian universities; (3) to stimulate interest in scientific research and to develop a body of trained technicians and scientists by means of scholarships.

In the new building in which the Council's work will be carried on and expanded, approximately 250,000 square feet of floor space is provided. Plans have been made to include a special laboratory for high-voltage electricity and another for testing construction material used in buildings and bridges. The installation of a testing machine of 3,000,000 lb. capacity is contemplated.

There are undoubtedly many technical problems which are peculiar to Canada alone, which can most effectively and most economically be solved by a laboratory co-operating with industry. Research in the new National Laboratories will not, however, be confined to those problems peculiar to Canada; the laboratories will embark on an extremely broad programme of research in electrical engineering. In anticipation of this broad programme every reasonable effort is being made to provide adequate services for investigating any problems which may arise. In the installation of services the Laboratory has attempted to provide those which will be of greatest general use, making provision at the same time for the future installation of more elaborate services as time and finances permit, and as the demand for them arises.

Space for electrical engineering research has been set aside at one end of a laboratory, roughly 30ft. wide, and having a head room of approximately 28ft. Associated with this space are a mezzanine floor and smaller units which will be devoted to some of the less cumbersome investigations and to office accommodation. Steam, air, water, &c., are available, and in the immediate future the following electrical services will be available:—(1) Direct current at variable voltage up to 240 volts; (2) 60-cycle alternating current at variable voltage up to 1100 volts, single or three-phase; (3) 25-cycle alternating current at variable voltage up to 1100 volts, single or three-phase; (4) variable voltage from batteries for special work requiring extremely steady currents. The A.C. frequency may be varied somewhat, and it is expected to increase the voltage range for both alternating and direct current. The present tendency towards high voltage study is not being overlooked, and plans are being made for high-voltage equipment, probably up to 750,000 volts, with a possible capacity of 400 kVA. While this range is rather modest, it is the maximum which can be installed in the available space, and undoubtedly will prove valuable for many investigations. It is hoped that at some future time a higher voltage equipment will be installed in an isolated building, especially designed for the purpose and situated so as to reduce interference to a mimimum.

In buildings known as "The National Research Laboratories Annexe" a programme of investigation has been embarked upon in the fields of aeronautics, biology and agriculture, chemistry, physics, textiles, electrical and physical standardisation.

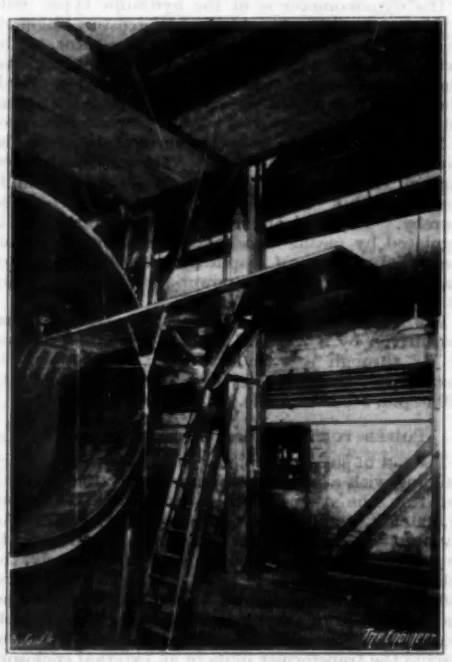
AERONAUTICAL RESEARCH.

The aeronautical research laboratories, which were opened for use last spring, served to remove a remarkable anomaly. The Dominion Government had previously been unable to carry out its own regulations with regard to the testing of aeronautical equipment for export. This equipment, under the regulations, must be tested before being sold for export, and until last spring the testing had to be done in private plants.

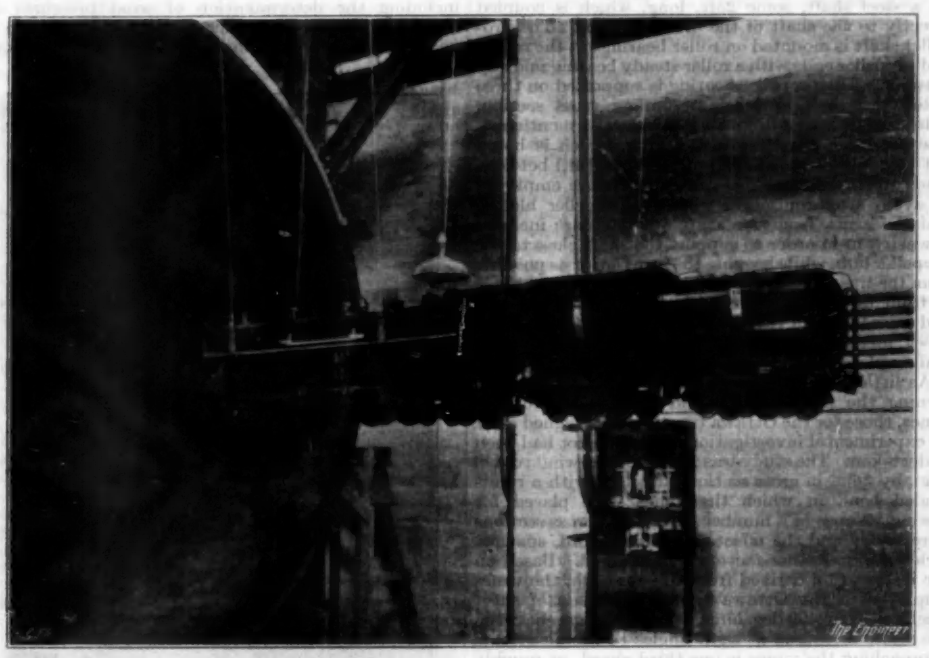
For testing models of aeroplanes and seaplanes, the following facilities have been provided:—(1) A wind tunnel for aerodynamic research and testing, 9ft. in diameter, in which a 13ft. propeller can develop an air speed of over 125 miles per hour; (2) a towing tank, 400ft. long, 8ft. wide, and 6ft. deep, for the testing of seaplane floats, hulls, and high-speed surface craft; (3) complete engine testing plant, capable of accommodating aero-engines of any type and of absorbing powers up to 1000 horse-power at speeds up to 2500 revolutions per minute.

The building in which the wind tunnel was to be housed was already in existence on the Council's property, and was of such form that a double return tunnel, with the plane of the circuits horizontal, could be housed to better advantage than a single return. The dimensions of the building were sufficient to permit the construction of a tunnel having an air stream not larger than 9ft. in diameter. A small hydraulic power plant was available on the property, having a minimum continuous generating capacity of 600 H.P. at low water. It was originally proposed to employ the whole output of this plant for the wind tunnel. Accordingly, the decision was made to construct a 9ft. diameter, 600 H.P., open-jet, double return wind tunnel. Design was started in September, 1929, and construction in November, 1929. The tunnel was first operated at full power early in June, 1931.

The nozzle of the wind tunnel is constructed partly of reinforced concrete and partly of wood. The contraction in area in the nozzle is over 4½ to 1, and the bursting pressure on the walls of the square section is about 55 lb. per square foot at maximum air speeds. The wooden portion of the nozzle is constructed of staves of British Columbia cedar with steel hoops, and is held by means of eight tie rods to a heavy steel ring anchored to the face of the concrete portion of the nozzle. The attachment is so arranged that adjustment of the nozzle is possible in order to align the jet. The honeycomb is composed of straight and crimped strips spot welded together in units, and is situated within a structural steel frame set in the

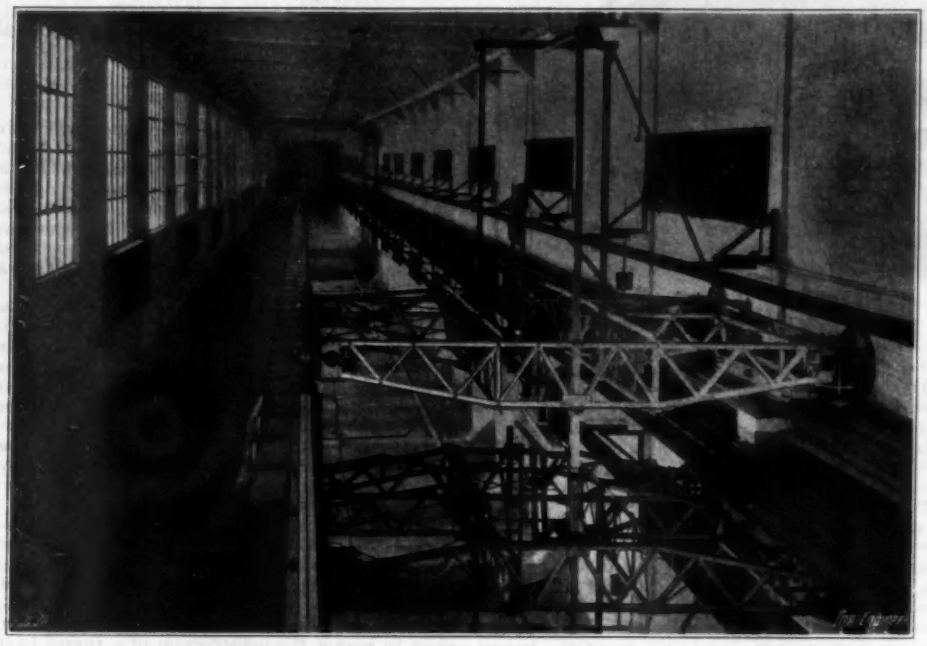


AEROPLANE SKI UNDER TEST



CANADIAN NATIONAL LOCOMOTIVE MODEL IN WIND TUNNEL

concrete of the tunnel. The material of the honeycomb is of 26 gauge non-corrosive alloy. The cells are trapezoidal in cross section, averaging 2in. to a side and are 9in. long. The collecting bell and expanding cone are constructed of B.C. cedar staves, those of the bell being shaped to the required curvature. The bell and cone are supported on structural steel cradles. The large end of the cone fits into a recess turned in a cast iron ring embedded in the concrete of the transition section, and is held thereto by means of a series of bolts. Provision has been made for the insertion of a cylindrical section between the nozzle and the collecting bell, should it be desired to enclose the jet for high-speed work.



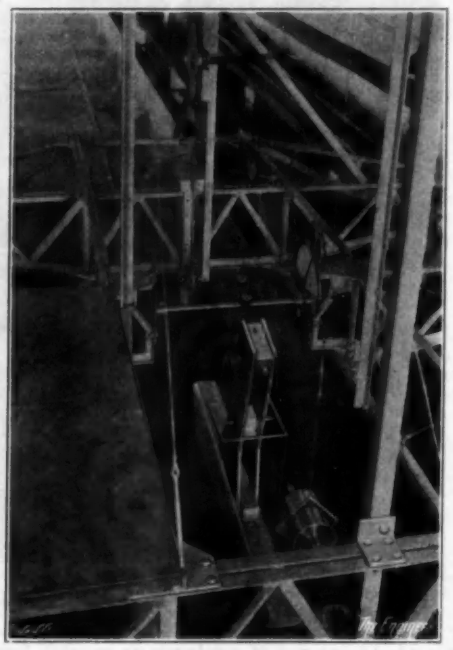
TEST TANK AND TRAVELLING CARRIAGE

The propeller supplying the draught is of the usual aircraft type, with four adjustable duralumin blades, held on an alloy steel hub. Its maximum speed when absorbing 600 H.P. is 1000 r.p.m., at which speed the tip velocity is about 680 f.p.s. The propeller is carried on a steel shaft, some 25ft. long, which is coupled directly to the shaft of the driving motor. The propeller shaft is mounted on roller bearings at the motor and propeller ends with a roller steady bearing midway between. The propeller bearing is supported on three radial cast iron arms of streamline cross section, bolted to the cast iron ring previously mentioned. The propeller turns inside this ring, which is bored out to permit a small clearance (about ¼in.) between blade tip and ring. Three radial arms are employed to avoid synchronisation with the propeller blades, and the arms, from the shaft outward, are inclined downstream in order to support the shaft close to the propeller hub, while keeping the arms as far as possible from the tips of the propeller blades. The shaft extends in front of the propeller to carry a wooden spinner, and is enclosed in rear of the propeller in a tapering sheet metal casing. The shaft passes through a sealing plate in the tunnel wall to the motor coupling.

As little published information was available concerning the proper shape and arrangement of the vanes, those for the Ottawa tunnel were designed after an experimental investigation of the subject had been undertaken. The study was made using a wind tunnel 18in. by 36in. in cross section, arranged with a right-angled bend in which the vanes were placed for testing. Vanes of a number of different cross sections were tested and the effect of profile, chord, spacing, incidence, and other factors were studied. Based on the information derived from this research, the vanes employed in the Ottawa tunnel are made of sheet steel, rolled to a 90 deg. circular arc. The gap between the vanes measured at right angles to the air-stream approaching the vanes is one-third chord, or roughly one-half chord measured along the diagonal of the corner. The vanes are supported at the ends only, any spacers or stiffeners between them having been found to have a detrimental effect on the velocity distribution behind the vanes.

Power for the wind tunnel is supplied from a hydraulic turbine-driven, 1000-kVA, 2200-volt, three-phase alternator in the power plant on the property. The plant contains two alternators, either of which can be isolated to supply the wind tunnel only, thus avoiding any mutual interference between the wind tunnel and other laboratory loads being supplied from the plant. An electrical machine room is provided at the propeller end of the wind tunnel building. The 2200-volt current entering the building passes to a 2200-volt panel and thence to the main motor generator set. This set comprises a 760 H.P., 2200-volt, three-phase, 60-cycle synchronous motor, and a 2000-ampère, 250-volt, variable voltage D.C. generator, together with the necessary exciters. The set is started by a semi-automatic starter and may be stopped by a push button control from any one of a number of stations. Between the generator and the propeller motor the current passes through the D.C. control panel. The propeller motor is of the shunt type with commutating poles, and has a continuous rating of 600 H.P. at 1000 r.p.m. with 40 deg. Cent. rise of temperature and a two-hour 25 per cent. overload capacity at about 1075 r.p.m. A speed range from under 100 r.p.m. to the overload maximum is provided. Complete protective devices and meter equipment are provided. In addition, a 50 H.P. induction motor, variable voltage, D.C. generator set, complete with control equipment, is provided for supplying current for testing model propellers in the tunnel.

In addition to purely aeronautical work, much other work may be conveniently done in the wind tunnel, including the determination of wind pressures on buildings, towers, and other structures, the design of windmills and ventilators, wind effects on transmission cables, air resistance of motor cars and locomotives, and the calibration of instruments.



TANK CARRIAGE AND MODEL

TEST TANK.

In deciding upon the dimensions to be adopted for the tank for testing seaplane floats, hulls, &c., it was necessary to compromise. Fortunately, the decision was somewhat simplified in that a building or rather two buildings were available on the site of the Laboratories, which, with comparatively little alteration, could be converted into a single building 400ft. long. The cross section is 18ft. wide by 16ft. high. This building is of reinforced concrete and brick construction and bedrock is but a few feet below the surface.

The tank is constructed of heavy reinforced concrete with tapered walls, a heavy base, and rounded corners. The top of the tank is placed about 42in. above the floor level to permit the convenient observation of wave formation, &c. The walls, at the top, have an inward projecting flange to reduce splashing. The carriage runs on 55-lb. rails laid on top of the tank sides. The rails are planed level on top, welded together, and ground to bring the top surface parallel with the water surface. The head of one rail, in addition, is ground on the top sides to as nearly a straight line as possible to serve as a guide rail.

The structural steel carriage of the tank is carried on four cast iron wheels, turned accurately to the same diameter, and mounted on shafts carried in roller bearings. There is, in addition, a pair of guide rollers at each end of the carriage on one side, each pair consisting of one rigidly mounted roller running in contact with the machined outside of the rail head and one roller mounted on a swinging arm held in contact with the inside of the rail head by a stiff spring. Two similar devices, but provided with shoes operating on the other rail, are used for decelerating the car. The use of these shoes promotes a positive braking action, which is little affected by water on the rails and which avoids the danger of wearing flats on the track wheels or of damaging the ground rail surface by slipping. The shoes are applied automatically with the cutting off of the power at the end of the constant-speed portion of the run.

A 25 H.P. shunt-wound motor provides the motive power for accelerating and driving the carriage. The motor is supplied with current at constant voltage from a controlled motor generator set in the machine room of the wind tunnel building, the transmission being effected through large-diameter trolley wires carried on the wall of the building. A speed of at least 20ft. per second can be secured. With a constant speed run of 150ft. the period for measurement is about 7½ seconds. The carriage is also provided with a side outrigger for carrying an observer in a position convenient for observing and photographing the wave formation.

POWER PLANT EQUIPMENT.

A complete engine testing plant has been installed, which is capable of accommodating aircraft engines of any type, air or water-cooled, tractor or pusher, and with right or left-hand rotation. The equipment is stated to be unique, in that provision is made for applying thrusts to the crank shaft corresponding to propeller thrusts up to 6000 lb. This thrust is applied by means of weights acting through a bell crank on the carriage on which the dynamometer is mounted.

The dynamometer is of the hydraulic type, built by Heenan and Froude, Ltd., of Worcester, England. In this dynamometer the shaft carries a rotor, in the faces of which are formed semi-elliptical pockets. The internal faces of the casing are similarly recessed. The pockets in the rotor and casing together form elliptical chambers, around which the water circulates at high speed, the vortices thus formed absorbing the power developed by the engine. The water circulated through the casing, not only provides the hydraulic resistance, but carries away the heat generated thereby. The load applied by the dynamometer is regulated by means of a hand wheel which controls the radial position of diaphragms between the rotor and casing by which the power-absorbing cups may be masked to any desired extent.

For testing air-cooled engines a large centrifugal fan, driven by a 250 H.P. motor, discharges a blast of air through a cylindrical duct and adjustable nozzle, past the engine cylinders. Air speeds up to 130 m.p.h. are obtainable.

POWER FOR MAIN LABORATORY BUILDING.

Instead of supplying power to the main laboratory building with a 550-volt, three-phase system, as provided in the original plans and specifications, an 11,000-volt, three-phase system was requested. An investigation indicated that this change could readily be justified on economic grounds. Unfortunately, the sub-basement space in the new building did not allow sufficient headroom for an 11,000-volt transformer, and it was felt undesirable to utilise any more valuable space for this service. It thus became a question of placing the transformer units in an external enclosure or placing them in an underground vault. The former alternative was incompatible with an attractive appearance and hence it was agreed to provide a vault in proximity to the heating plant.

Since a large part of the load throughout the building would be single-phase, some anxiety was felt lest the three-phase system should become badly unbalanced. When this matter was brought to the attention of the consulting engineers, they suggested a three-phase distribution system throughout the building, supplied from transformer banks of three-phase units rather than single-phase units. These three-phase transformers inherently re-establish the balance on the primary side, regardless of the degree of unbalance on the secondary side.

The power requirements for the building were analysed by comparing the service with those of other laboratories. Unfortunately, no other laboratory had comparable power requirements, so that it

was difficult to estimate closely the load which might be anticipated. However, it is felt that provision has been made for adequate service without extravagance.

Research Work Being Carried On.

In addition to aeronautical research and testing, some of the investigations in progress at the present time are:—Heat insulation qualities of building boards and refractories; waste caused by static electricity in aerial surveying cameras; radio frequency standardisation; pitching moments of aircraft skis; magnesite (the possibilities of using magnesite in many directions are being explored and at the moment active work is in progress on its use in refrigerators and in metal smelting furnaces); asbestos (a new moulding composition which is claimed to be stronger than Portland cement has been developed). The possibility of replacing imported magnesium salts and other imported chemicals with products made from waste asbestos rock is opened up by another line of research. The scientific control of tanning, the use of scrap leather for glue manufacture, and the possibility of preparing a satisfactory tanning extract from the waste sulphite liquor of pulp mills are being studied. A new line of attack on the problem of producing motor spirit in profitable quantities from waste gas by subjecting it to a heat process is now being followed up. Interesting studies on the subject of synthetic rubber have some relation to the problem of the utilisation of waste natural gas, and a method has been indicated by which a synthetic product nearer in quality to natural rubber than the synthetic rubber made in Germany during the war can be prepared.

Research on the L.M.S. Railway.*

In 1930 a Director of Research was appointed with a small secretariat, and also a research committee composed of the chief technical officers of the company, together with a group of distinguished scientists with wide experience of research in engineering, chemistry, and physics. There were thus brought together at a time when the railways were feeling acutely the need for cheaper and more efficient methods, engineers who knew the railway problems and scientists who could help in their solution. The partnership quickly became close and effective.

The first problem facing the committee was to decide on the most profitable subjects to attack. The wide range of railway activities provides an immense number of alternatives, and it was essential to choose those which offered an early prospect of increased net revenue. A number of suggestions were put forward by the officers, and in order to submit the field to a thorough scrutiny, the committee examined a list of the amounts spent each year by the company in the purchase of various materials, and also the company's annual accounts, in order to see which of the larger items of expenditure offered opportunities for research. It soon became clear that the most favourable subjects for investigation were connected with the maintenance of rolling stock and fuel economy, but in addition a number of minor problems were disclosed which it was desirable to attack without delay.

The research committee met first two years ago and consequently much of their work has not yet reached the stage of giving practical returns, but tangible results have already been obtained in a number of directions. The first major problems to be attacked were connected with the maintenance of rolling stock. The sums spent on this in 1929 are given below and although considerable reductions had been made since amalgamation, the magnitude of the expenditure made it a good field for research.

Maintenance of Rolling Stock.

	£
Locomotives and tenders	4,709,997
Rail motor vehicles (steam and electric)	192,667
Coaching vehicles	2,473,808
Merchandise and mineral vehicles	2,516,297
	9,892,769

In addition to the above, improvements in efficiency or design may affect the cost of cleaning and preparation for use, as well as such working costs as lubrication. Such expenditure in 1929 amounted to:—

	£
Cleaning and preparation—	
Locomotives	688,738
Carriages and wagons	547,456
Lubrication—	
Locomotives	118,113
Carriages and wagons	141,279
	1,495,586

An examination of repair costs shows that these are mainly incurred in two ways which may be described under the headings "Day-to-day Maintenance" and "Workshop Repairs."

Day-to-day maintenance covers all the minor repairs which can be effected without taking the unit out of service. This work is closely connected with the constant inspection and examination necessary to ensure the high standard of safety maintained on British railways. It will be appreciated that this work is highly important and the efficiency with which it is carried out has an important bearing on the total maintenance costs. Any reduction in this expenditure can only be made by improved organisation unless the standard of maintenance is lowered. As a result of careful investigation it has been found that considerable economies could be effected by improved facilities for carrying out the work and the better distribution of the staff at the strategic points on the system.

Workshop repairs may be regarded as the repair work carried out in the main factories when the unit has been taken out of traffic. This repair work is classified under various headings, but the repairs carried out when the unit is taken out of service are best covered by the term "Periodic Overhaul." A unit is taken out of service owing to some major repairs being required. To effect this repair alone and return the unit into service is not always practicable, and in any case is not an economic policy. When a vehicle is in a workshop it must be put into such condition that it will be capable of remaining in service for the longest period possible. It will be seen, therefore, that major repairs are determining factors in repair costs and that, by prolonging the period between any major repairs, maintenance costs may be greatly reduced.

One of the major repairs necessitating rolling stock being taken out of traffic is the re-turning of tires. The effect of worn tires differs somewhat on various classes of vehicle. On locomotives the permissible wear is determined mainly by consideration of safety, whereas on carriages it is determined by its effect on smooth running. On non-passenger carrying stock the limit of wear may be determined by safe running condition, but it is probable that if the wear is such as to give rise to instability, this sets up severe vibration which reacts badly on repair costs for a long period before the safety limit is reached. The problem of reducing tire wear is both mechanical and metallurgical, and both these aspects are being studied.

The investigation of the precise motion of the tire relative to the rail is fundamental both for a proper understanding of the mechanism of wear and of the riding of vehicles, since this probably depends on the motion of each individual pair of wheels.

With a view to determining the ideal tire profile which will enable good running conditions to be maintained for the longest possible periods, some full-scale experiments have been carried out, but whilst certain general results have emerged a full-scale experiment is not ideal in the early stages of such a research. If the essential factors can be reproduced on a small scale, laboratory work under controlled conditions will greatly accelerate the investigation. For this reason we are following with interest a series of experiments now being carried out in the Engineering Laboratory at Cambridge by Mr. A. R. Jackson, under the guidance of Professor C. E. Inglis. A model track of 1ft. gauge has been laid down, and the motion of a single pair of wheels studied. In the first experiments the influence of varying the coning of tires on the stability of running has been determined, and the investigation is now proceeding to the case of the four-wheeled bogie.

The determination of the relative value of different materials for resisting wear is a difficult problem, since, if experimental tires are put into service, it is impossible to know the exact conditions under which they have been running, and a long time must elapse before the wear is measurable. What is needed is a test under controlled conditions which will give a result within a reasonable time. The Japanese built a circular track for testing the wear of rails and tires, but this involves a special type of motion, is expensive, and occupies considerable space. We are now attempting to design a wear-testing machine which will combine the advantage of a research apparatus with the ability to test rails and tires of normal section. If this is successful it will be invaluable for selecting the most promising classes of steel and the most suitable profiles for subsequent trials.

Maintenance of Locomotives.

In the case of locomotives the major repair which determines shopping is that of the fire-box. There are two methods of attacking the problem of maintaining this in good condition for a longer period, both of which are being pursued. In the first place, improvements in design and construction are being studied to determine the extent to which improved methods in construction and modification in the physical characteristics of the materials used will prolong the life. Greater accuracy has been attained in the manufacture of the stays and tapping of the stay holes, ensuring better fitting of the stays; the size and shape of the stay heads have been studied and experiments made with stays and plates of different materials. Many of these improvements have originated through the investigation made by the British Non-Ferrous Metals Research Association. To expedite the development of the new materials suggested by this investigation, all experimental work in this field has been concentrated at Horwich under Mr. G. N. Shawcross. The period in service can be still further prolonged if the working conditions are improved by the prevention of scale formation and accumulation of dirt in the boiler. To achieve this, improvements have been made in the facilities for washing out boilers, but what is of still greater importance, steps are being taken to ensure the boilers being supplied with softened water. A large proportion of the water in England is distinctly hard and the scale which is deposited on the heating surfaces of the boilers is a direct cause of frequent repairs to the fire-box and tubes. In order to investigate the possibilities of softening our water on a large scale a small committee was appointed under the chairmanship of Dr. P. Lewis Dale, containing a representative of the motive power department, and members of the research committee. After a thorough survey of the water supplies on the whole system, and of the various methods available for softening, it was decided to install lime-soda softening plants, capable of treating over 3,000,000,000 gallons of water annually, at twenty-eight points on the main lines between London and the North. Some of these plants are already in operation, and when the scheme is completed we anticipate that 1600 locomotives will benefit from the use of softened water.

If by a combination of the two methods referred to the period of shopping for locomotives can be increased by 10 per cent., a reduction in the annual repair costs to locomotives of about £150,000 will be effected, in addition to a saving of £6000 in interest costs.

Fuel Economy.

The largest single item in our list of purchases is locomotive coal, and the cost of the coal consumed in 1929 amounted to £4,808,669. An expenditure of this magnitude obviously invited the closest scrutiny with a view to seeing whether research could effect economy and, as a result, two lines of work have been started, one dealing with the question of the wind resistance of trains, the other with the combustion process in the locomotive boiler.

(*a*) *Wind Resistance of Trains.*—This problem has been studied in the past by several authorities—notably Sir John Aspinall in this country and Professor Goss in America—by means of dynamometer car tests. The tests were made on complete trains, and fairly concordant results were obtained giving formulæ of the type $P = KV^2$, where P is the pressure per foot of cross section, V the velocity in miles per hour, and K a constant depending on the number of vehicles making up the train. Dynamometer car tests of this kind, however, suffer from two serious drawbacks, since the external conditions of wind direction and velocity are not under complete control, and it is difficult to ascertain the distribution of the resistance between the different units of the train. For these reasons these investigations do not appear to have resulted in any very definite advances.

The development of wind tunnel technique, involving the use of small-scale models, has in recent years opened up a new method of investigating our problem under strictly controlled conditions. This technique has played a vital part in the evolution of the aeroplane and high-speed motor car, and now holds an established position as a basis of design in these two fields. An instance of the application of the wind tunnel methods to the problem of the wind resistance of trains is the work of Maurain in France, but his experiments were incomplete and were only carried out at zero yaw. Tests of special streamlined vehicles have also been carried out recently in Germany and America, but no complete investigations relating to existing trains of normal design have yet been undertaken.

Whilst it is realised that wind resistance is only a part of the total resistance to the motion of a train, and that in any case it is only an important factor at relatively high speeds, we decided that a thorough analysis of the wind resistance of a train at various angles of yaw would be desirable. Only in this way could we determine the possible value of streamlining or other modifications.

Having reached this decision it was at once obvious that we had neither the equipment nor the *personnel* to carry out the investigations ourselves, and we arranged to co-operate with the London and North-Eastern Railway in a programme of work to be carried out in the wind tunnel at the National Physical Laboratory. The first series of tests consists in measuring at various angles of yaw the resistance both of the whole train and of each vehicle in it by means of one-fortieth scale models of a "Royal Scot" locomotive, tender, and six coaches. This test will then be repeated with similar models of L.N.E.R. coaches in which the ends are streamlined. The second series of tests consists of similar measurements on an "ideal" train composed of wooden prisms having faired cross sections derived from that of the actual train. A comparison of the results will, it is hoped, settle finally the relative importance of wind resistance and the possible economies which may be effected by varying the external form of the rolling stock and the distances between coaches.

The results of some tests on the L.M.S. train have just been received, and they show that, in the case of a ten-coach train, 29 per cent. of the wind resistance is accounted for by the engine and tender, 8½ per cent. by the first coach, 6½ per cent. by each subsequent coach, except the tenth, for which the proportion is 9½ per cent. The results also show that at 60 miles an hour, without any head wind, approximately 400 H.P. is absorbed in overcoming the air resistance of such a train; this amounts to over 25 per cent. of the power developed by the locomotive under these conditions.

(*b*) *The Combustion Process in a Locomotive Boiler.*—An investigation of this subject was added to the remit to the joint committee which was investigating the question of water softening. The available evidence on which to form an opinion as to the efficiency of combustion is meagre. Brislee's experiments on the L.N.W.R. were limited to the determination of carbon monoxide in the smoke-box gases, Herbert's work on the L.M.S.R. was concerned only with a special aspect of combustion in the fire-box, whilst Fry's work in America—carried out on stationary testing plants—was not entirely conclusive, since the attempts made to catch the unburnt fuel were somewhat unsuccessful and the tests made at high rates of combustion did not tally with the indirect method used for determining the loss.

It seemed desirable, therefore, to attempt experimental work on locomotives in normal service with a view to drawing up a complete heat balance for a modern locomotive boiler, so that the various losses could be measured separately.

A full investigation of the heat balance of a boiler involves the following determinations:—

(*a*) Rate of firing and calorific value of the coal.
(*b*) Volume and temperature of air supplied to the fire-box.
(*c*) Weight of water evaporated and quality of the steam.
(*d*) Loss through unburnt fuel in ashpan.
(*e*) Loss through unburnt fuel in smoke-box.
(*f*) Loss through unburnt fuel ejected through the chimney.
(*g*) Loss due to presence of carbon monoxide in exhaust gases.
(*h*) Loss due to heat of exhaust gases.
(*i*) Loss due to radiation.

The most difficult problem has been to devise a method of determining the unburnt fuel ejected through the chimney, but the following means have been devised whereby it is hoped that a continuous record of this loss can be made.

The method consists in extracting continuously a proportion of the products of combustion leaving the tubes and analysing these before and after their passage through a high-temperature combustion tube. A known amount of oxygen is added to enable the combustion of carbon monoxide and solid particles of carbon to be effected, and the increase in carbon dioxide content which is measured enables the loss to be assessed. The necessary analytical apparatus has been developed in conjunction with the Cambridge Instrument Company, and will be placed in the dynamometer car between the tender and the train.

At the present moment an engine of the "Royal Scot" class is being fitted with this apparatus, and if it proves effective it will form a useful equipment for investigating the performance of future designs.

* From a paper entitled "Scientific Research on the London, Midland and Scottish Railway," read by Sir Harold Hartley at the Buxton meeting of the Institute of Transport. June 1st.

Electrification of French Railways.

UNDER the title "Quelque Réflexions sur un Développement de l'Electrification des Chemins de Fer Français," a brochure which severely criticises recent proposals has been published by the O.P.T.A. (Office pour le Perfectionnement de la Traction Autonome sur les Chemins de Fer). The pamphlet discusses in detail the balance sheet advanced in favour of French railway electrification, and as many of the arguments and figures are applicable to this and other countries as well as to France, we have thought it worth while to offer a rough rendering into English of the essential parts.

It is certain that the electrification of railways is attractive both to travellers and to property owners. Furthermore, in such cases as suburban and mountain railways it presents an incontestably interesting solution of the traffic problem. On these advantages all the world is agreed, but the adoption of electrification of railways on a large scale implies such considerable expenditure of capital that it is essential to know in the first place if the operation will be financially successful.

A project for the realisation of a new and vast programme of electrification for French railways was formally advanced last year. The proposal was to electrify 3000 kiloms. selected from the lines most favourable to electrification; that is to say, the most active lines of the seven systems. Taking these new lines in conjunction with the 1600 kiloms. already electrified or in course of electrification, about 35 per cent. of the whole national traffic would be included for a length of lines not exceeding 8 per cent. of the French railway system, and would lock up capital of about 5,000,000,000f. (£40 million).

It is obvious that such an enormous investment would not be justified unless it was truly advantageous. For this reason it has been deemed necessary to examine the programme in question from all points of view and to draw conclusions. As a starting point for this investigation the following table, which is based on the data prepared for the project in question for the years 1929 and 1930 has been drawn up.

TABLE I.—*Balance Sheet.*

Electrification—projected.	Steam operation—actual.
Item I. Interest on new capital (interest and amortisation, 50 years): 6·5 per cent. on 3,325,000,000f. =216,000,000f.	
Item II. Expense of operation and upkeep of electric lines, sub-stations, and diverse apparatus: 1·5 per cent. on 3,325,000,000f. =50,000,000f.	
Item III. Provision for the renewal before 50 years of the electrical installation: None.	
Item IV. Electricity on H.T. side of transformers in sub-stations: 780,000,000 kWh at 0·2f. =156,000,000f.	Coal on the tenders of locomotives: 1,800,000 tonne at mean price of 160f. per tonne =288,000,000f.
Item V.—Operation and Upkeep of Locomotives. 3·60f. per train kilometre on 69,000,000 train kilometres =248,000,000f.	6·5f. on 69,000,000 train kilometres =448,000,000f.
Totals, 670,000,000f.	736,000,000f.

Balance, exclusive of purchase of electric locomotives, in favour of electrification, 66,000,000f. = 2 per cent. on capital invested.

It will be perceived at once that for a scheme so comprehensive in nature the return upon the capital invested, no more than 2 per cent., is insignificant, particularly when it is remembered that the purchase of the indispensable electric locomotives is not included, and that the most profitable lines have been selected for consideration. The purchase of the locomotives, as will be shown later, would involve an additional expenditure of about 2,000,000,000f.

From *Item I.* in *Table I.* it appears that the equipment of 3000 kiloms. of line would cost about 1,000,000f. per kilometre on the average, everything included. The fitting of electric radiators to several thousand vehicles and the purchase of a certain number of heating wagons which will be necessary in certain parts will cost about 325,000,000f. It is probable, however, that, as has happened in other cases, these provisional figures will, in fact, be exceeded. It would be possible to show, for instance, that on a certain great French system the estimates for electrification had been exceeded by no less than 50 per cent. The present estimates have, for example, been based on copper bars at 6f. per kilo., and beams at 60f. per 100 kilos., but these are slump prices and particularly low. It would be imprudent to base an estimate on them covering several years to come. It may be observed, in passing, that in the estimate of 3,325,000,000f. the importation of copper will involve an expenditure of 500,000,000f. Such an outlay cannot be made without grave inconvenience to the balance of French trade.

To sum up under this heading, it may be observed that for a capital expenditure exceeding the estimates by no more than 10 per cent. the annual balance sheet for electrification would be unfavourably affected to the extent of 21,000,000f. If the cost of interest increased by no more than 1 per cent. the balance sheet for electrification would be adversely affected to the extent of 33,000,000f.

Item II., Table I.—In the absence of useful data it is not possible to discuss the figure of 1·5 per cent. which appears in the estimates. However, it may be mentioned that one of the great French systems which has experience of electrification has estimated the expenditure under this head at 1·76 per cent. of the capital, despite the fact that all the material is new.

Item III., Table I.—No annual provision has been made for the renewal of contact lines, of sub-stations, and of diverse apparatus. That is to say, that the estimate for electrification implies that the installation will last for fifty years without need of repairs to any of the parts. Such endurance could hardly be expected. It would be wiser to provide for the complete renewal of the contact lines every twenty years and the material of the sub-stations every thirty-five years, to say nothing about the replacement of transmission towers, &c. Hence it is reasonable to count upon an annual expenditure for renewal, and according to our estimates the amount ought to be 1 per cent., although that is inferior to the allowance made on foreign lines, and although it is remembered that within such a long period of years rejuvenation of material will certainly be called for. However, if no more than 1 per cent. is allowed for the renewal of lines, sub-stations, and apparatus, the annual balance sheet for electrification will be adversely affected to the extent of 35,000,000f.

Item IV., Table I.—Accepting the figure of 0·20f. as the cost of current at the high-tension terminals of the sub-stations as given in Table I., it should be noted that the project proposes that the railway systems shall not use their own current, but buy it, both in order to avoid the locking up of considerable capital and to permit the electrical supply companies to sell their excess current. It would seem, however, that no contract has been made with the companies to sell current over a number of years at 20 centimes, and the possibility that they could do so must be regarded with doubt, in view of the fact that in general 20 centimes is the price charged at the point of departure from power-houses, whilst in this case the price at the sub-stations is being considered. Actual figures show that the cost of a kilowatt-hour at the sub-stations for electrified lines is materially higher. Thus, on the Etat it is 27 centimes; on the Paris-Orleans 34 centimes; and on Swiss railways 23 centimes as taken from their own power-houses and 37 centimes if bought from other companies. It is true that the Midi obtains current at 15 centimes, but it is generated in hydraulic power stations operated by the company and situated in the neighbourhood of the railway system. In view of these facts it seems not improbable that if the supply companies sign a contract to supply current at 20 centimes over a long period of years, they may find themselves obliged to increase the cost to private and industrial consumers in consequence of the loss on railway current. Alternatively, the contract may not be entered into, or if entered into, in order to facilitate the electrification scheme, may not hold for long. It must be noted, however, that an augmentation of as little as 5 centimes in the price per kilowatt-hour would affect the balance sheet of electrification adversely to the extent of 39,000,000f. On the other hand, it is not unreasonable to think that the price of coal consumed by steam locomotives has attained its maximum at the mean value of 160f. per ton on the tender. As far back as 1913 certain systems paid no more than 130f., and that figure is likely to represent the average price for the present year. In fact, in February last the figure fell to as low as 110f. per ton. Finally, and this is a fundamental point, the figures given under Item IV. of the balance sheet imply that 1 kilowatt-hour at the high-tension terminals of the sub-station is equivalent to 2·2 kilos. of coal on the tenders of locomotives. This equivalence is strongly contestable for the reasons which are now to be given. In the first place, an effort has been made to discover the actual consumption of current per ton-kilometre on electrified systems in France and in other countries. On one of the great French systems in 1930 the consumption at the high-tension terminals at the sub-station—allowing 90 per cent. efficiency for the sub-station and 90 per cent. for the distribution—was 24·5 Watt-hours per ton-kilometre in round figures. Only part of the necessary shunting was included in this figure, the other part being done by steam locomotives. But it is to be noted that no electric train heating was included, the heating having been effected by heating wagons. If heating were done by electric radiators and if all the shunting were done by electric locomotives one would have to count probably upon a consumption in round figures of 30 Watt-hours per ton-kilometre.

On another great French railway system a figure of 29 Watt-hours per ton-kilometre is given for the consumption, but in this case also an addition would have to be made for heating and shunting.

Published statistics for the electrified line Gothenburg-Stockholm show a consumption in round figures of 32 Watt-hours per ton-kilometre, and it is doubtful that this figure includes heating and shunting.

The total consumption per ton-kilometre on the Swiss Federal Railways is 43 Watt-hours, all heating not being included.

Finally, an unchallengeable authority on electrification has estimated that on all the electrified lines in France there has been consumed in recent years 315,000,000 of kilowatt-hours measured at the high-tension terminals of the sub-stations to haul 9,295,000,000 ton-kilometres without taking into account all the expenditure on heating and shunting. These figures give a consumption of 34 Watt-hours per ton-kilometre as a mean minimum.

From the figures given above one may regard as very moderate an estimate of 31 Watt-hours per ton-kilometre, heating and shunting included, for a collection of lines giving passenger, goods, and even suburban services such as are included in the programme of electrification. It should be observed, moreover, that since all these electrifications are of recent date there is little or no probability of great advances in the future, since the highest limits of efficiency have already been reached.

Let us now consider the similar figures for steam-operated systems. They may be placed in two groups. On the Chemins de Fer de l'Etat Français the mean total consumption of coal per ton-kilometre, everything included, notably train heating, was 58 grammes* on the lines Paris–Le Mans and Paris–Le Havre.

On the lines Strasbourg–Basle and Mulhouse–Belfort of the Alsace-Lorraine system the fuel consumption in 1930 was 43 grammes per ton-kilometre, everything included.

On the Est in the same year and for all the main lines to Paris the figure was 51·2 grammes per ton-kilometre, everything included.

On the Nord for the same year the same equivalent figure was 59 grammes per ton-kilometre.

The figure in Table II. may therefore be taken as representing the relative consumptions in Watt-hours and coal on the tender for the two systems of haulage. A further table, No. III., shows the equivalence if the services are divided into fast and slow.

TABLE II.

System.	Consumption of current in Wh per tonne kilom. at H.T. of sub-station.	Consumption of coal in grammes per tonne kilom. on tenders.	Equivalence. kWh—coal.
State	31	58·2	1 : 1·85
Alsace - Lorraine	,,	43	1 : 1·4
Est	,,	51·2	1 : 1·65
Nord, whole system	,,	59	1 : 1·9

TABLE III.—*Consumption of Coal and Electricity per Tonne-kilometre Without any Allowance for Shunting and Train Heating.*

Service.	Steam, "Nord."	Electric, Great French system.	Equivalence.
Fast and express trains ..	36·9 grammes	22·2 Wh	1 : 1·65
Slow	19·75 grammes	15·3 Wh	1 : 1·3

It appears from figures published in 1930 that on the Paris–Orleans system 1 kilowatt-hour was the equivalent of 1·98 kilos. of coal on the locomotive, exclusive of train heating.

From all this it will be seen that as far as comparative results and costs are concerned the equivalence of 1 kilowatt-hour with 2·2 kilos. of coal is not justified, even despite the fact that the steam locomotives in question have an average age of no less than thirty years. To the French figures given above may be added the following taken from other countries:—Swiss railways, 1 kilowatt-hour: 1·75 kilos. of coal; Bavarian Railways, 1 kilowatt-hour: 1·4 kilos. of coal (in this case the locomotives are modern); and Swedish Railways, 1 kilowatt-hour: 1·5 kilos. of coal.

From this examination it would appear that the equivalence is not 1 to 2·2, as given in the balance sheet, but 1 to 1·75, involving an error in the balance sheet for electrification of at least 50,000,000f. Moreover, it must not be forgotten that, as already indicated, the average age of the steam locomotives concerned is in the neighbourhood of thirty years, and that many of them are used upon services for which they were not specifically designed, as, for instance, when old main line engines are transferred to secondary lines. If a complete stock of new steam engines, all, moreover, designed for the services on which they were to be employed, was considered, it would be found that the figure of 1·75 would be reduced to 1·5, making the estimate for the economy by electrification wrong by 78,000,000f. instead of the 50,000,000f. mentioned above.

Item V.—The cost for operation and maintenance of steam locomotives is well known, but the similar figure for electric locomotives is not known. The balance sheet for electrification estimates an advantage of 2·90f. per train kilometre, but the P.O. estimates an advantage of no more than 2f. in its returns for 1930, and the State Railways for the electrified suburban lines gives a figure of 2·37f. Furthermore, the figure of 6·5f. for steam trains is excessive, the figures for the Alsace-Lorraine line being 5·86f., for the Est slightly over 3f., and for the Etat 6·06f. Finally, in place of the 3·5f. given in the estimates for electrified operation, the Etat on its suburban railways spends 4·36f. per train kilometre, and abroad, on the Swiss Railways for example, the expenditure in 1929 was 5·5f.

Hence, if in place of the estimated 2·90f. per train kilometre, which is to be gained by electrification, it is reduced to 2f., the true figure, the balance sheet will show a further deficit of 60,000,000f.

The position with regard to the cost of locomotives is shown in Table IV.

TABLE IV.

Electrification—projected.	Steam locomotives—actual.
Purchase of 1050 locomotives at about 2,000,000f. each. 8 per cent. for interest and amortisation in 25 years: 160,000,000f.	Replacement in 30 years of 2100 existing locomotives at 1,100,000f. with tenders. Purchase of 70 locomotives each year: 77,000,000f.

Adverse balance for electrification, 83,000,000f.

* One gramme per ton-kilom. = ·0035 lb. per ton-mile.

THE London and North-Eastern Railway, as successor to the North British Company, obtains access to Aberdeen by running powers over the former Caledonian—now London, Midland and Scottish—from Kinnaber Junction. The approach to the latter important point has always been handicapped by over 9 miles of the line immediately south being single-tracked. As related in our last two annual "Railway Engineering" articles, the section between Inverkeilor and Usan and that between Montrose and Hillside are being converted to double line, and the work now approaches completion. The 2 miles intervening between Usan and Montrose include a steel viaduct of sixteen spans, and a brick arch viaduct, also of sixteen spans, together with a long length of deep cutting through solid rock. The expense of doubling this portion would, therefore, be very great and is not, at present, deemed to be justified.

Railway and Road Matters.

THE membership of the National Union of Railwaymen, as officially recorded by the union, was 295,268 at the end of last year, compared with 334,835 at the end of 1930, a net decrease of 39,567. The membership total reached the peak in 1919, at 481,081. The following year it fell to 457,836, and it has fluctuated since.

THE Southern Railway Company has found loud speakers useful for informing the passengers standing in the rush evening hours at London Bridge the places served by trains that are then entering that station. The London, Midland and Scottish is now following that example by installing five loud speakers at Ryhl for the holiday traffic.

IN order to meet the requirements of the paint trade, the L.M.S. Railway Company has fitted shelves into containers so that large numbers of tins can be loaded in such a way that there is no pressure on the lower tiers, the tins resting on the shelves in much the same way as in the shop of the retailer. The adoption of this modified form of container has, it is claimed, led to an increased use of this particular form of transport.

THE last annual report of the railway administration of South Africa says that in some parts of that country, particularly in semi-arid districts, the water available is, if used without treatment, a fruitful source of boiler trouble and consequent engine failure. Two years ago a branch of engineering chemistry was established in the department of the chief mechanical engineer, and the present report says that experiments showed that the corrosive action of these waters can very easily be stopped by the addition of small quantities of calcium hydrate.

THE closing of the L.M.S. carriage and wagon shops at Newton Heath, referred to herein on May 13th, was considered as having such an unfortunate influence on business conditions and on the rates, that it was proposed by the local authorities to send a deputation to see Sir Josiah Stamp. He replied, however, that representatives of the men's unions had been to Euston and had gone away convinced that the step was irrevocable. It was not, therefore, likely that the proposed deputation would do better than the men's own representatives.

THE London, Midland and Scottish Railway some time ago placed the divisional and district traffic officers more directly under the commercial superintendent. That involved touch with over 2500 stations, and the problem of linking those stations with the respective traffic officers and the latter with headquarters has put a strain on the company's telephone system. The weakness is now to be remedied by the provision of carrier trunk circuits, whereby three additional speech channels will be provided over an existing pair of wires. During the present year fifteen additional physical circuits and fourteen additional carrier trunk circuits will be completed.

THE Union of Soviet Socialistic Republics has placed an order with Beyer, Peacock and Co., Ltd., for a "Beyer-Garratt" locomotive of great size and power. This engine will be the heaviest steam locomotive ever built in Europe, and the first engine of this type to be introduced in Russia. The wheel arrangement will be 4–8–2, 2–8–4, the maximum axle load being 19 tons, and the tractive effort over 70,000 lb. The coupled wheels will be 5ft. in diameter, while the grate area will be some 84 square feet. The engine will carry 16 tons of coal and will be tested in various parts of Russia, including Siberia, where the winter temperatures are very considerably below zero. The total length of the locomotive will be over 100ft.

WHEN a delegation from the Royal Commission on London Traffic was in the United States in the autumn of 1903, it received great assistance in the matters in which it was concerned from Mr. W. Barclay Parsons, whose death on May 16th was recently reported. The usefulness of the evidence given by Mr. Parsons lay in the fact that he was the chief engineer to the Board of Rapid Transit for the City of New York, which body was then engaged on building the first section of the New York "subway" or underground system. He answered 230 questions, and his evidence filled ten pages of closely printed matter in the blue-book containing the information gathered by the Royal Commission when in the United States. He also handed in a statement that filled five pages.

A STATEMENT recently made on behalf of the railway companies indicates that the experiments conducted with steel sleepers during the last three or four years are regarded as so satisfactory that these sleepers may be used on a far larger scale. There are at present nearly half a million laid in short lengths in different parts of the country, where they are being subjected to exhaustive tests. The principal technical difficulties are the inability to use steel sleepers on electrified or track-circuited lines and crossing work, and the reluctance to use them in tunnels and at water troughs until further experience is gained of their behaviour. There is nothing, it is stated, which need stand in the way of extending their use if they prove satisfactory in respect of their life period in service.

FOLLOWING our comments of May 13th as to the collision of January 6th at Didcot East Junction, and the report thereon by Lieut.-Colonel Anderson, we would say that an interesting feature of that accident was that the train of milk empties that overran the signals and caused the collision was, in common with all the Great Western trains on that section, fitted with automatic train control. As the distant signal was against the train, the "warning" signal was given on the engine as it approached the signal, and it applied the brake. The driver acknowledged the warning, and blew off the brake; in other words, he cancelled the warning and the accompanying control of the brake. It should be added that Colonel Anderson said in his report that "there is no cause for criticism of the automatic train control equipment. . . . The accident was not brought about by any failure on the part of this equipment to act in the manner intended, but by breach of block rules on the part of the signalman and by failure of the engineman to observe and obey the home signal, in spite of the reminder afforded by the apparatus at the distant signal."

Notes and Memoranda.

AT a petroleum refinery at West Tulsa, Oklahoma, natural brine from a deep well is used as cooling water in the condensers. The brine is concentrated to such an extent that 400 tons of salt are recovered a day, together with considerable quantities of bromide and iodine.

IN its investigation of seasoning of logs as a means of preventing their loss through shrinkage, the Forest Products Laboratories of the Forest Service, Ottawa, found that seasoning birch logs under cover in a shed for ten weeks greatly improved their capacity for floating, but comparatively little increase in buoyancy was effected by prolonging the seasoning beyond that period.

IN order to increase the bearing power of the clay soil under a building in America, a number of 2in. holes were drilled in the clay and filled with cement grout at a pressure of 3000 lb. per square inch. The cement took as long as seventy-two hours to set, on account of the exclusion of air; but by adding 1 lb. of baking powder to each bag of cement this setting time was reduced to fifteen hours.

WHAT the effect of double-deck elevators will be upon growth in the height of buildings is not, says *Power*, of New York, determinable, since so many other factors of economics enter into the decision. By this device, skyscrapers much greater in height than our present buildings are now possible, for economic elevator service has heretofore been the chief deterrent in height extension.

A TORPEDO which was lost in Weymouth Bay in 1921 when being tested for the Japanese Navy, has recently been recovered by the Whitehead Torpedo Factory officials. Its presence on the sea bed just off the 4000 m. torpedo range in the middle of Weymouth Bay was detected by magnetic apparatus. A diver then recovered the torpedo, which was found to be covered with barnacles. There was still, however, air in the torpedo's air vessel.

WOOD pipe for ventilating enjoys a great deal of popularity among tunnel contractors and engineers on the Pacific Coast, where it is being employed in sizes from 12in. to 24in. diameter in the new C.P.R. tunnel under Vancouver and on other work. It has many advantages over the thin tin pipe usually used for that purpose. It will not collapse or be punctured by flying fragments during blasting operations. With an improved type of coupling now used it can be connected up without the usual driving.

ON Saturday of last week, Sir Frank Dyson, the Astronomer Royal, opened the new photographic equatorial dome at the Norman Lockyer Observatory, Sidmouth, and afterwards inspected the giant telescope. It contains four cameras with lenses of different sizes and different focal lengths, and will photograph large areas of sky. Long exposures hithero impossible in England will be obtained and it is hoped to make new discoveries among the smaller planets and comets. The dome and telescope were presented by Dr. Robert Mond.

OWING to its favourable geographical position in relation to England, Hamburg maintains its position as the largest German importing centre for British coal. Against 3,674,829 tons imported at Hamburg (including Altona and Harburg) in 1930, the total in 1931 was 2,907,017 tons, the difference of 767,812 tons representing a decline of a round 20 per cent. Hamburg's participation in the total import was 78 per cent. The total amount of coke imported from England at Hamburg in 1931 was 159,773 tons out of a total import into Germany of 265,507 tons.

THE first steel coal barge built for the port of New York was launched last month at the Staten Island plant of United Dry Docks, Inc., for the Berwind-White Coal Mining Company, and was christened "Eureka No. 100." The new barge is electrically welded throughout, on the patented reverse channel system, a development of Mr. Johannes Kjekstad, consulting welding engineer for United Dry Docks. It is 130ft. long overall, its moulded beam is 35ft., and its moulded depth 12ft. 6in. It carries 1200 long tons of coal, in cargo space of 50,400 cubic feet to top of hatch, and has about 12in. freeboard when so laden.

FOUR high-speed seaplanes, it is understood, are being prepared at Desenzano, on Lake Garda, for an attempt on the world air speed record of 407½ miles per hour established by Flight Lieutenant G. H. Stainforth in the Schneider Trophy flights last year. The official attempt on the record will be made, it is understood, between June 5th and June 15th. The machines, we understand, are each furnished with two engines driving two propellers mounted on one shaft, the propellers revolving in opposite directions. The experiment is being watched closely The two engines are stated to be designed to develop about 2500 H.P. and weigh about 2200 lb.

THE wireless industry of Canada continued to expand during 1931. One of the best measures of its progress is the number of licences issued for receiving sets. In 1931 there was an increase of nearly 40,000 in the number, while, compared with 1929, the record year in so many industries, the advance was more than 50 per cent. Similarly, there was an increase of over 70 per cent. in the production of receiving sets in 1931 compared with the previous year, while the increase in sales on the same comparison was over 25 per cent. The number of receiving sets sold in Canada in 1931 was 286,122. Compared with the figures for 1930, when 223,228 sets were sold, there was, however, a decline in value.

A WORLD'S record in shaft sinking was achieved at the West Rand Consolidated Mines in March at the new South Shaft, which was sunk a distance of 400ft. at a cost of £24 13s. 8d. a foot. The April figures, says the *South African Mining and Engineering Journal*, show that the March record has been exceeded by 2ft., the April total footage sunk being 389ft., an average of 13ft. per day. There was one working day less in April than in March. At the same rate the March total would have been 402ft. The sinking was commenced in January last, and the total depth now reached is close on 1400ft. It is now anticipated that the ultimate depth of 4000ft. will be reached by the end of the present year, which would constitute another record.

Miscellanea.

THE Cosulich Line announces that its new motor liner "Neptunia" will enter the South American service on October 5th.

IT is reported that a new plant for the manufacture of concentrated nitric acid, and with a capacity of 5000 tons per year, is to be erected in Roumania.

THE Russian journal *Electritchestvo* states that the Soviet Government intends to erect a line between Svire, Leningrad, and Dnieprostoi, to transmit power at a pressure of 400,000 volts. Leningrad is about 800 miles from the plant.

THE Hull City Council has now approved the new proposals for the construction of a pedestrian and vehicular bridge over the river Humber. The whole cost of the bridge will, it is proposed, be met by the issue of £2,000,000 5 per cent. debentures.

A RAPID decline has taken place in the imports of foreign batteries into this country during the first three months of the current year. The figures available indicate that the drop is nearly equal to 80 per cent. of the figure for the first three months of 1931.

THE production of metallic cadmium in the United States in 1931 amounted to 1,050,529 lb., valued at 409,706 dollars, and was equivalent to only 38 per cent. of the record high output established in 1930. The value in 1931 was, however, only 23 per cent. of the value in 1930.

WITHIN the last few days the divers from the Italian salvage ship "Artiglio," who recently resumed their efforts to recover the bullion from the sunken P. and O. liner "Egypt," off the coast of Brittany, have made good progress, and an early success is expected if weather conditions remain propitious.

UNDER the new Finance Bill of France, 100,000,000f. is provided as advances in respect of extensions of electricity supply in rural areas during the coming fiscal year, a sum of 5,000,000f. as subsidies towards the cost of new hydro-electric plants, and 4,000,000f. as subsidies in respect of new power transmission lines.

DURING the first three months of the year the total exports of British wireless goods (including complete sets, valves, components, and radiogramophones) were valued at £279,380, as compared with £219,987 for the corresponding period of 1931. One London firm, in one market alone, increased its exports by no less than 800 per cent.

A FEW days ago passengers on board the "Flying Scotsman" and those on the Imperial Airways liner "Heracles" conversed with each other by wireless as they travelled northwards at nearly 90 miles an hour. It was the first occasion on which messages had been exchanged between a train and an aeroplane, and the experiment was very successful.

THE Crosser Bill, which has been approved by the Commerce Committee of the House of Representatives, will authorise airship companies to obtain mail contracts similar to those which are granted to steamships. Contractors will be required to operate American-built ships of approved design, capable of carrying at least 10,000 lb. of mail 2000 miles or more without refuelling.

THE United States Bureau of Standards has published a handbook for the purpose of supplying new data and tables which are derived from the revised values of the ultimate fibre stresses of chestnut Western red cedar and Southern pine, three woods which have been very extensively used in electrical line construction. It also deals with the strength of wooden poles, while new tables are given for the bending moments caused by wind pressures upon poles of various heights and circumferences.

DURING recent excavations at North Shields four sections of wooden pipe, remains of the town's original water service of more than 100 years ago, were unearthed. They were tree trunks, on which the bark had been left, and each was 5ft. or 6ft. in length and about 6in. in diameter. Each section was bored with a hole 3in. in diameter and tapered at one end to fit into another section, thus making a complete and effective joint. The pipes were in a good state of preservation, and on one length the bark was almost intact.

THE Manchester Ship Canal Company, Ship Canal House, King-street, Manchester, has published a plan of the Canal, with descriptive matter and information relating to the port of Manchester and a separate plan of the Manchester docks, with insets showing respectively the railway and canal connections with the port and the principal industrial areas of England, for which Manchester is the nearest port. There are sites available for factories and works, with deep-water frontage, direct connection with all the main railway systems, trunk roads, and inland waterways.

COMMERCIAL stocks of bituminous coal, which is used largely for industrial purposes, amounted to 30,050,000 tons on April 1st, 1932, according to the quarterly survey just completed by the United States Bureau of Mines. In comparison with the stocks on January 1st, this was a decline of 5,450,000 tons. In comparison with the same date a year ago, when stocks amounted to 29,500,000 tons, the present reserves show an increase of 1·9 per cent. In the meantime, however, consumption has been declining, so that in terms of day's supply the present stocks are substantially greater than those of a year ago.

IT has been estimated that the shipbuilding yards of the United Kingdom will build in the next five years sixty vessels of the passenger and intermediate liner type, totalling 850,000 tons gross, and 250 vessels of the cargo liner type, totalling 1,650,000 tons gross. This gives a average yearly building of 500,000 tons, and in the last eleven years the average tonnage built in the United Kingdom of these types of ships has been 400,000 tons gross. According to Mr. W. J. Lovett, of Workman, Clark (1928), Ltd., the probability is that future building will be faster. Modern practice now enables one ton of fuel to carry twice the amount of cargo carried by a ship of pre-war design.

THE BENUE BRIDGE IN NIGERIA IN COURSE OF CONSTRUCTION

(*For description see page 603*)

FIG. 20—PANORAMIC VIEW FROM SOUTH BANK—OCTOBER 6, 1931

FIG. 21—PANORAMIC VIEW FROM SOUTH BANK—MARCH 27, 1932

The Engineer

JUNE 3, 1932.

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QUALITY AND PRICE.

IT seems probable that a question which has long vexed manufacturers and merchants will at length be fully considered. At many times within the past twenty years complaints that the price of British engineering products was too high because the quality was too good have been made by individuals, and by trade commissions to foreign lands. We can recall no occasion upon which these complaints have been seriously debated by British engineers. Desultory discussion has, indeed, followed their appearance, but as a rule they have been rather impatiently dismissed with the assertion that British foreign trade has been built up on quality; that British engineering products are the best in the world, and that we must maintain our reputation and traditions or perish. Some, indeed, have gone so far as to argue that superior quality is now all we have to offer in competition with rival nations and that if we surrender it we shall have to give up all hopes of retaining foreign markets. There has never been any serious attempt to discover a *via media*; there has been no calm and logical discussion of the pros and cons. The subject, as we say, has been dismissed with a curt *non possumus*. It has, however, been revived within the last few weeks by a method which makes an easy escape from it impossible. Hitherto the attack, if we may so describe it, has been dispersed; now it is direct and concentrated. We are not at liberty, at the moment, to give full details, but we may say that the British Standards Institution has received from the British Chamber of Commerce in Buenos Aires a request to consider if British standards are not unnecessarily high and if they cannot be lowered with a view to a corresponding reduction in price. As a sample of the contents of the communication, we quote one of the charges:—"Electrical (Generators and Motors). Unless a special industrial type is put forward and smaller frame sizes offered with a higher temperature rise, it will be found that British goods are out of line. British firms, however, object to this procedure, and in one case would not supply with their name-plate on. Our method of manufacture maintains too high a standard to suit the ordinary user here, due to the resultant high price."

It would have been the easiest course for the B.S.I. to answer the British Chamber of Commerce in Buenos Aires in the now well recognised terms. We are glad to say that it has taken the wiser course of circulating the Chamber's letter to industrialists and other interested parties and inviting their comments. What the next step may be it is as yet too soon to inquire, but we cannot imagine that the B.S.I. will permit the question to be shelved without adequate discussion. It is too serious for that. We may even hope that all the answers will in due course be made public and that the B.S.I. will publish the considered reply that it makes to the British Chamber of Commerce in Buenos Aires. We count ourselves fortunate in being able at this early stage to place one of the answers before our readers. It was written for the British Engineers' Association by Mr. David Bremner, the Director of that Association, and we thank both him and the B.S.I. for permission to make long extracts from it. They will be found on page 619 of this issue. No one who reads Mr. Bremner's memorandum can fail to be struck with its lucidity and open-mindedness. Recognising the great asset which British engineers have "laboriously created" for the quality of their products, he remarks that it is of "vital importance to distinguish between what is actual or real and what is only apparent or illusory" in our standards of excellence. There we have an indication of the lines upon which a careful investigation might be conducted. It is not impossible that in some cases our aims are too high for a competitive industry. It is possible that, certainly outside and probably within the sphere of standardisation, we are perpetuating what might be described as traditional "quality," and that a departure from custom might be made without material sacrifice of durability and safety. "The claim," writes Mr. Bremner, "that British engineering standards, British engineering practice and the resulting quality of British machinery are 'superior' to those of our competitors, should be re-examined critically and honestly, in the light of the knowledge and experience of to-day, without burking the pertinent question as to whether we are always in the right and our competitors are always in the wrong." That is all we ask; that the question should not, as hitherto, be lightly dismissed with a few set phrases, but that it should be "re-examined critically and honestly." No one can challenge Mr. Bremner's further statement that "machinery made in accordance with standards and practice differing from our own is doing the greater part of the world's work to-day. For all practical purposes, much of it is as good as ours, and some of it is even superior in some respects to its British counterpart." We recognise, with Mr. Bremner, the difficulties and objections to a lowering of standards, but, at the same time, we cannot be blind to the frequent statements that both our quality and our prices are too high for foreign markets, and, in consequence, to the desirability of discovering some means by which the great reputation of British engineers may be maintained, but at a lower price than the hazard of some of our finest markets.

In putting forward this plea for full consideration of the problems involved, it is only fair, even at this stage, to indicate some of the lines of thought which support the maintenance of the highest standards. It must not be forgotten, for instance, that many other nations have now instituted standardising associations and that the probable tendency of such bodies will be the improvement of quality. It is conceivable, indeed, that, owing to international activities, many standards of an international character will in time be formulated. It may be that those standards will be based on the present British practice; on the other hand, a compromise between British and foreign practice may be adopted. In either case, if they are truly international, the end will be the same; all countries will offer the same quality and price will be ruled by other considerations. Again, it may be argued that since the United Kingdom is the greatest buyer in the world, she is in a position to set her own prices and, in consequence, to maintain her own standards, regardless of what they cost. Or, again, it may be argued that a great many of our standards have been established for the purpose of protecting the life and limbs of our people and, whatever other countries may do, we dare not adopt practice which is less safe. These and other arguments may be, and no doubt will be, advanced to support the retention of British standards of excellence. But when we set against them the fact, attested by many competent witnesses, that we are losing some of our trade in consequence, the necessity for the inquiry cannot be gainsaid.

Pooling Traffic Receipts on Railways.

THE announcement made on Saturday last that, as from July 1st, the London, Midland and Scottish and the London and North-Eastern Railways are to pool their receipts from competitive traffic, both passenger and goods, has been associated with the views expressed by the Royal Commission on Transport. We hardly think it likely that the able men at the head of those two great companies would need any such lead. We suggest rather that this is a result of the expiration or cancellation of the old agreements, made by some of the former constituents of the two companies. Agreements for the "apportionment of tolls" were sanctioned generally by the Railways' Clauses Act, 1845; and by the Railways' Clauses Act, 1863, they had to be approved by the Board of Trade. One very important agreement was that made in 1862 between the London and North-Western and the Lancashire and Yorkshire as it applied to nearly all the traffic except local journeys in Lancashire and the West Riding of Yorkshire. That agreement, amended in its apportionments every ten years, remained in being until 1908, when it was replaced by a wider one. That event was the sequel to the most important agreement as to traffic ever made in this country—that between the two great rivals, the L. and N.W. and the Midland, in 1907, which was extended the following year to embrace the Lancashire and Yorkshire Railway also. The proposed working union between the Great Northern, Great Eastern and Great Central followed, and led to the appointment of a Departmental Committee on June 17th, 1909, which said, in contrast to the requirement made, later, in the Act of 1921, that if "a company makes an arrangement, such as a pooling agreement, with another company . . . it seems desirable that any such arrangement should be made known." Earlier in its report the same Committee expressed its concurrence with the opinion of the Devonshire Royal Commission of 1867 that "railway companies should be allowed to enter into valid working and traffic agreements without the necessity of obtaining powers from Parliament or the Board of Trade"—a recommendation which the 1909 Committee added had, however, never been embodied in general legislation.

Despite the unanimous desire of the 1908 Committee, which included such traders as Mr. Russell Rea and Mr. Alexander Siemens, and had in its membership of ten only one representative of the railways, thus to assist the companies, the intention of the Ministry of Transport to exercise a firm control over the railways was evident in the requirements made in this and other respects in the Railways Act of 1921. It was therein laid down that it should not be lawful for any company, without the consent of the Minister, to enter into agreements with any other company "for the allocation of traffic or the pooling of receipts or otherwise for effecting a combination." Fortunately for the companies, there does not appear to be anything in the present proposals which does not fall within the purpose of pooling arrangements in the past. They are not antagonistic to the traders' interests, but, by helping the companies, are helping their customers. The need for the more economical working of our railways is so apparent that they need not be urged. The case was well put by Mr. Whitelaw, the L. and N.E.R. chairman, before the Hartlepools Chamber of Commerce on May 10th and we feel that all that is necessary to commend it is to note his reply to those who contended that it would be the beginning of monopoly. He asked, "Which was the better: a prosperous railway service with monopoly or an incompetent railway service with the old competition which ruined railway companies in the past?" and he added: "When we go to the Ministry of Transport for this 'monopoly' it will be to carry your goods by the shortest route, by the cheapest way, and not to tumble over each other to sneak each other's traffic. That is the railway policy which holds my mind at the present moment. I ask for fair consideration of that policy from the Chambers of Commerce, and I hope business men will not hold up their hands and say, 'This is a monopoly!'" We may add, as regards the companies, that the apportionment will be on the basis of the receipts from each company's competitive traffic for the three years 1928, 1929, and 1930. It is not the intention to take the figures for each route, *e.g.*, between London and

Aberdeen or Edinburgh and Leeds, but the total receipts from all competitive traffic will be divided in the ratio arrived at from the average of the three years named. Prior to pooling, certain allowances, *e.g.*, for terminals and work, other than rail conveyance, and for certain working expenses peculiar to each company, will be deducted. It is of interest to note that this arrangement follows that proposed in the London Passenger Transport Bill. One important benefit that will result from these proposals is that joint properties, like that of the Cheshire Lines Committee and the Midland and Great Northern Joint Committee, will no longer be separately administered, and that will result in considerable economies. Even the smallest of joint lines necessitate some exclusive supervision, accountancy, and clerical work, and so further economy will result from that being no longer necessary on such lines as the Swinton and Knottingly, Otley and Ilkley, Sheffield and Midland, Dundee and Arbroath, Dumbarton and Balloch, &c., and the dozens of joint stations like Huddersfield, Halifax, Bradford (Exchange), and Leeds (Central and New Stations).

Looking at the question from the traders' and public's point of view, it must be remembered that better results from the railways mean greater benefits all round. The competition of road transport has put the companies on their mettle, with consequent advantages to traders. It is hardly likely, then, that they will do anything that will encourage the transfer of more traffic from rail to road. The results of the poolings of twenty-five years ago, already referred to, were hardly noticeable. Some facilities were withdrawn, but they were compensated for by improved services over the former rival routes. Another factor that counts is the pride each company takes in the services it offers. The London, Midland and Scottish has practically no competition for its London–Liverpool and London–Manchester traffic, but the journey is still made in the 3½ hours that ruled when the L. and N. W. had to face the competition of the Midland. The routing of goods traffic may be changed, but most of it flows in defined well-regulated channels, which are not likely to be disturbed to any appreciable degree. Where economies are most to be looked for is in respect of town receiving offices, canvassing, cartage, and the closing down of some of the goods depôts. The last is, however, likely to be less fruitful than might be thought, as most goods stations are old structures and ill-adapted to take any further business, whilst to connect them up to the lines serving the depôts to be closed may mean expensive physical junctions. Generally, then, the benefits which the companies will be able to give the traders, because of the resultant economies, will outweigh any possible disadvantages. So much so, that it may be anticipated that the Great Western and Southern may pool the receipts from their competitive traffic, and the G.W. and the L.M.S. The former of these two does not compete with the L. and N.E.R.

Oil Engines for Pipe Lines.

ON more than one occasion recently we have referred to the large pipe line which is to be laid from Irak through Palestine to Haifa and Tripoli, by the Irak Petroleum Company, Ltd. Orders for pipes amounting to over half a million pounds and for steel buildings and other requirements have already been placed in this country. An important part of the scheme will be the pumping units, which, no doubt, will be oil-engine driven. We estimate that between forty and fifty units will be required with designed engine outputs up to 500 B.H.P. It is probable that inquiries for this plant will be issued during the next few months, early delivery being an important factor for the completion of the work in the required time.

The general features of the plant required being assumed, the question may be raised as to whether the British oil engine industry is in a position to deal with an order of such magnitude and to give satisfactory terms of delivery. We say, without hesitation, that several of the leading oil engine builders in this country can quite well adapt their works programme in order to accommodate and deal effectively with such an order. What is very important for the industry is that every effort should be put forward in order to secure, if possible, the whole of the order for Great Britain. No doubt the rival claims of vertical, and horizontal, opposed-pistons, four and two-stroke operation, air and airless injection, normal or pressure charging will all be put forward. From the point of view of the user, it would seem desirable that with the object of reducing as far as possible the number of spare parts to be carried, the number of engines of the same design should be as large as possible. Although many firms are capable of dealing with the whole of the order for between forty and fifty engines, it may be found desirable, with a view to expediting delivery, to divide the order into two or three parts. If this is done, there would be no difficulty in arranging either for as few as possible different designs of unit, or, once the desired design has been fixed, to manufacture, under agreement between makers, a standard engine which would incorporate all the newest and most important features. In the case of marine engines, this practice has already been adopted with success by Mr. Sterry B. Freeman, for engines fitted in Holt Line ships, while Mr. C. Zulver has carried out a similar plan for the large number of engines recently installed in new tankers for the Anglo-Saxon Petroleum Company. It can be assumed, we think, that engine designs have now advanced sufficiently in the direction of standardisation, mainly as the direct result of the initiative of the different oil engine building firms to enable land engines to be constructed under similar conditions to the marine engines above referred to. In the matter of engine performance, we have happily an authoritative record of working costs, which has for many years been carefully kept by the Diesel Engine Users Association. Another factor of primary importance in securing the order for British firms is the question of engine price. We believe that we are correct in stating that although most makers are agreed upon a basis price for the production of an engine of given output, no agreement as to engine prices among makers of British oil engines has so far been found to be possible. On the other hand, makers of turbines, generators, and condensing plant have long since agreed on basis prices with, we know, considerable advantage to that branch of the industry. In the face of a possible large order, such as that for the Irak pipe line pumping equipment, would it not be desirable for British oil engine makers to get together and to review this important aspect of the industry? Quite recently appeals have been made for a common export sales policy, with a view to placing the industry in a better position to deal with overseas trade, and the time would now seem opportune to undertake such a task. If unduly high prices prevail, then some of the work will undoubtedly pass into Continental hands, while, on the other hand, too low prices would not enable the best to be put into the plant and its accessories, and in the long run would not be advantageous either to the builder or to the user.

In the above we have only been able to indicate one or two directions in which, it seems to us, the present position may be prepared to enable British builders to secure a large oil engine order. Should they be successful, it is certain that the high prestige which British oil engines now enjoy abroad will be increased. In conclusion, we may remind our readers that when discussing the rival claims of coal and oil, and laying emphasis on the money spent on oil fuel not always remaining in this country, the large amount of money spent by the oil companies in connection with drilling and refining plant, and transportation by land and sea is often overlooked. In the past, the British engineering industry has benefited to no small extent by the orders which have been placed for pipes and pumping equipment, refining plant, and oil tankers, both steam and motor propelled. We hope that the initiative shown by British oil engine builders in the present situation will ensure the success desired in the matter of the oil engine pumping plant which will be required for the Irak pipe line scheme.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

ROAD AND RAIL.

SIR,—At the present time, when our railways do not pay and much misconception appears to exist about the superiority of road over rail transport, it is perhaps worth while comparing the two methods of mechanical transport, as it is the most efficient means that will give us the cheapest transport in the long run.

Modern transport depends upon the heat engine for power, that is, the external and internal combustion engine—electricity being only a medium of conversion.

Rankine defined efficiency as the ratio of useful work to energy expended. No doubt he was particularly referring to the heat engine, but if we substitute £ s. d. for energy—that is, the cost of conversion and application—the definition is equally applicable to the subject under discussion.

In referring to the efficiency of mechanical transport, the vehicle and the road on which it runs must be taken together, as the one is useless without the other. This fact must never be lost sight of or we shall arrive at false conclusions.

There are two efficiencies to be considered: the mechanical efficiency and the commercial efficiency, and, in addition, reliability and safety cannot be ignored. The mechanical efficiency is plainly a technical term that relates to the proportion of useful work done by the power employed to do it, and provided the vehicle and the road retain that efficiency, it is possible to transport a certain weight in a given time for a certain expenditure in fuel.

In the heat engine the heat is the power. In the external combustion engine we do all we can to retain it; in the internal combustion engine we do all we can to reject it; therefore the internal combustion engine is not likely to rival the efficiency of the external combustion engine of the super power stations for mechanical traction.

It is true the steam locomotive has a low thermal efficiency; in other words, a high percentage of the heat units in a pound of fuel are lost in the process of conversion into mechanical power, but it has the advantage of great flexibility and a high percentage of the mechanical power is expended in useful work.

Though the thermal efficiency of the oil engine or motor is higher, that is, able to convert more heat units from a pound of fuel into mechanical power, it is no advantage if that power or energy is dissipated in useless work or for technical reasons cannot be made full use of. If there is excessive waste of the power generated and the cost of the fuel exceeds a certain figure it only tends to decrease the commercial efficiency of the work done, which is after all the ultimate goal in the whole problem of efficient mechanical transport. Still, it is possible the motor or internal combustion engine may reduce costs under certain conditions on our railways like electric traction, but this remains to be proved by experience.

The commercial efficiency is the cost of conveying the merchandise from the port of landing or place of production to the destination where it is required for use. Not only the expenditure in fuel and maintenance of the vehicle and the road on which it runs in proportion to the weight carried, but the capital cost, fair interest on the money invested, purchase of land, compensation, buildings, and every expense in connection therewith must be taken into account. Low capital cost often results in high maintenance expenses; on the other hand, high capital cost may be justified by economy in working. Again, money spent on reliability and safety is an insurance policy against damages and loss of life.

All credit is due to those who have brought the motor vehicle to such a high state of comfort and perfection, but they owe a debt to the State, which can never be repaid, for protecting their industry and providing the roads, without which that perfection could never have been attained.

There is no necessity to quote statistics to illustrate the tremendous difference between the power required to transport goods by road and rail. Think for a moment of the horse-power the engine has to develop to transport 250 tons of goods from London Docks to Leeds, say, in seven hours, and the horse-power the motor vehicles have to develop to transport that weight by the high road in the same time. The ratio between the power employed and the useful work done is colossal. The energy or power is simply wasted. It is obvious you cannot convey 10 tons on the high road profitably at the same rate and speed as you can on the railways. For one reason alone the high road is inferior in grade and construction for the purpose.

The precepts of James Watt and George Stephenson are as true to-day as they were a century ago. Is not steam the power of the super power station—the power that James Watt showed the world how to use efficiently and economically? Is not the railroad the road that George Stephenson showed the world was the cheapest and most efficient form of road on which heavy vehicles could run—due to the resilience of the track, the grade of the road, and distribution of the load, compared to the steep hills and unyielding construction of the highway? Are not our railroads with their easy grades and curves, resilient tracks, and unequalled durability the most efficient roads the world has ever seen?

You may convey your 10 tons quicker by inefficient means, but you will not convey them cheaper unless it is at the expense of someone else, and that is exactly what is occurring at the present day in mechanical transport on the highways. It is carried on at a rate which is not economic, at the expense of the railways and the public. There is an economic rate for mechanical transport on land in precisely the same way as there is an economic rate for mechanical transport at sea. The mechanical road vehicle is extravagant in power per person carried and per ton of goods conveyed, and this cannot be overcome without prohibitive capital expenditure.

Time is money; the actual speed on the journey does not concern the consignor and consignee; it is the dispatch and delivery from door to door that matters.

The conveyance of goods and passengers at the lowest rates in the shortest time from door to door will always appeal to the majority, and rightly so, and the sooner this facility in transport is placed on an economic basis the better for the country. But the public must be made to realise by the Government and the Press that reduced time in delivery from door to door by inefficient means cannot be had unless other forms of transport and other sections of the public are shouldered with the burden. It is in direct conflict with the unalterable laws of science and mechanics.

By all means let us have door-to-door delivery by express

goods traffic on the high road, regardless of the danger to life and limb which must be associated with it, if the people insist upon it as a necessity to a successful business, but it is only just to the rest of the community that they should pay for this luxury.

What is the remedy for the present unsatisfactory state of mechanical transport in this country? Our railways do not pay; our roads are congested; the loss of life is terrific; and the expense of transport for both goods and passengers is excessive. Road and rail transport companies must combine; if they will not the Government, who are responsible for the present state of affairs, should make them do so. It will be for the combined companies to draw up rates at an economic level; the heavier the load and quicker the delivery from door to door the higher the rate should be.

The value of motor transport is undeniable, and there seems to be no reason why a carefully organised combined service, both for passengers and goods, should not in course of time give us much quicker transport from door to door at less cost. But if motor transport on the high road is carried on as at present in competition with the railways, let us be careful in discarding the efficient for the inefficient mode of transport in our ceaseless endeavours for more speed, more convenience, more comfort, and less trouble, we do not impoverish our basic industries and bring hardship and ruin on large sections of the community.

To have cheap transport on a sound basis it is the ratio of useful work to energy expended that must be kept in view. Mechanical efficiency in the application of power has all but, if not quite, reached its maximum. It has given us cheap power to supply us with water, light, and transport, and wherever possible it behoves us to make the fullest use of this scientific achievement, if we desire real progress in industry and transport that will benefit the whole country. E. C. BOWDEN-SMITH, M.I. Mech. E.

London, S.W. 1, May 28th.

SURVIVAL OF THE CONSULTING ENGINEER.

SIR,—The thanks of all consulting engineers are due to you for the very concise and reasoned article in your issue of May 13th on "Consulting Engineers."

It is unreasonable to expect any class of people to submit themselves to a fixed code limiting their activities without they receive proper support from the other members of the industry, and this the consulting engineers at present do not.

There is one aspect of the question on which you have not touched; that is, the saving to the industry as a whole, and therefore to the country, which results from the employment of a consulting engineer.

Is it economical that half a dozen firms should each have to spend considerable time in working out a detailed scheme, and then when they have done that prepare their estimates, or is it better that the scheme should be prepared by one person and that all the contractors could then compete on level terms? If the first procedure is adopted, each firm is probably quoting on an entirely different scheme, and the purchaser, if a layman, generally is not in a position to judge the relative merits of the various proposals put before him. It may quite easily be, therefore, that he will accept the lowest price, although the scheme thereby adopted is not the one best suited for his requirements, and also that when the work is completed he will probably find that he has considerable bills for extras and additions.

If a consulting engineer draws up a scheme, each firm has merely to price out the items in the specification and the purchaser knows that he is getting competitive prices for definite work.

May 30th. WESTMINSTER.

SIR,—Your Leader of May 13th raises three fundamental questions:—

First, what minimum of experience justifies the title and profession of consulting engineer?

Secondly, what responsibility is assumed with the title?

Thirdly, what does the client receive from the consulting engineer which he cannot obtain direct from the manufacturer?

Only after consideration of these fundamentals can we justify or condemn the complaint you voice, that manufacturers are depriving the consulting engineer of his occupation.

First, the early consulting engineers were usually men who, like the two Stephensons, had attained to the position by their practical experience as railway, bridge, or engine makers. Their clients went to the fountain head, and they, as consulting engineers, assumed full responsibility for the advice they gave and the goods they delivered.

To-day, the consulting engineer may or may not have had such practical experience, and, more often than not, he is dependent on the contractor to advise him as to how the work required is to be executed.

Secondly, in the matter of responsibility, taking the case of locomotives as an example. A contractor is frequently asked to tender for designs which may be mechanically bad or impossible of execution within tons of the specified weight. Such designs usually represent the railway company's requisition, and it should be the first duty of the consulting engineer to correct error. In practice, this is usually left to the contractor in whose office the necessary calculations and drawings have to be made. These have to be submitted to and approved by the consulting engineer—often a lengthy and costly process—before work can proceed. Having approved the drawings, the consulting engineer, however, takes no responsibility for the result; should it be unsatisfactory, the contractor is left "holding the baby."

No doubt this is general consulting engineering practice in respect of power plant and mechanical installations generally—possibly even in bridge work—and it is bound to encourage the tendency which your article indicates.

Suppose, for instance, a colliery company, wishing to erect the best cleaning plant on the market. There are two sources of information—the users and the manufacturers of such plant. There are no others from which a consulting engineer can obtain information, and the colliery manager is, or should be, equally competent to advise his board, seeing, too, that the manufacturer will as a matter of course assume a responsibility for failure which the consulting engineer would repudiate. The manufacturer becomes *de jure* what he so often is *de facto*—the consulting engineer.

Thirdly, of those services which the consulting engineer does in fact usefully supply to his client, there are:—(1) Inspection of material under construction. Human nature being what it is, this is sometimes a necessary service, but it can be carried to the absurd. (2) Co-ordination of work being carried on in different establishments for overseas clients. (3) As a buying agent for such clients.

But something more than this is required to justify the proud title of "consulting engineer," and ensure its survival under present-day conditions and intense specialisation in manufacture. If the profession is to become wholly parasitical on the brains of the manufacturer, it will not deserve to survive.

Bath, May 28th. J. G. H. WARREN.

FIRES IN LINERS.

SIR,—The timely and important leading article "Fires Aboard Liners," published in THE ENGINEER of May 20th, will, I hope, receive the careful attention of all British shipowners and shipbuilders.

Recent disasters clearly indicate that insufficient study has been given to the circumstances which permit of fires being developed in passenger ships of such great magnitude, and with such awful rapidity in defiance of alarms, chemical appliances, well-equipped fire-extinguishing services, good organisation, and brave men.

The cause is fairly obvious—the presence everywhere of wooden bulkheads and fittings, which become thoroughly dried in the upper works by sun and wind, and, in the 'tween decks, by the pervasive heat from the machinery.

As you stated, in passenger ships fire-resisting bulkheads are required in the cabin spaces between decks, but their distance apart may be as much as 131ft. in those parts of the ship which are above the continuous bulkhead deck. The areas so enclosed are much too great. Within the areas so enclosed, beyond and above them any amount of wood may be fitted in the form of bulkheads, casings, furniture, &c., and this is subject to no regulations as to quality or treatment.

In a modern office building no architect would dream of installing such extensive woodwork, while in case of disaster outside assistance is likely to be much more quickly applied, and means of escape are much more readily arranged in buildings in a large town than on ships scattered on the wide oceans. Bad weather also is much more likely to lead to disastrous loss of life.

After years of investigation and trials, with varying degrees of success, a very severe system of fire-resisting impregnation has been found for treating timber for use in ships of the Royal Navy, and a factory has recently been erected in France for the similar treatment of timber for use in the French naval and mercantile marine. In a number of British-built passenger ships this process has also been adopted, but to a very limited extent. Mr. Theodore Ferris proposes to use large quantities of light metal alloys, and of metal-faced plywoods in any new U.S.A. liners.

Surely it is time that public opinion backed up the scientific processes referred to above by demanding that the materials used in new ships will not themselves be able to give assistance to the progress of fires at sea, whether the fires originate in accidents, defects of electrical appliances, carelessness of smokers, or the deliberate intention of evil-minded persons. The last sinister possibility makes the demand for improvement inexorable.

International action is most desirable in this matter to prevent British shipowners and shipbuilders being unduly handicapped by the bogey of extra cost. On the other hand, it is not wise to wait too long for this in face of a growing public demand which may have unfortunate effects on the length of the sailing list if the matter is not treated as very urgent, and duly attended to in all new passenger ships of every description.

J. H. NARBETH, C.B., M.I.N.A.,
late R.C.N.C.

St. Leonards-on-Sea, May 26th.

WATER DIVINING.

SIR,—I have been extremely interested in the correspondence on the subject of Water Divining, which has recently appeared in the columns of your paper, and also I may confess rather surprised, since the matter has been rather regarded as taboo in scientific and technical papers.

With this taboo attitude, indeed, I should have associated myself until a few years ago, 1926, to be precise, when, being invited to watch a fellow-engineer give a demonstration of water divining and reluctantly and sceptically trying myself, I found that I was an exceedingly responsive agent.

Since that period I have at odd times demonstrated the phenomenon to hundreds of others, mostly engineers, but I can only recall two cases outside my own family where the response has been conclusive. The immediate query which arose in each of these cases was, "Where the dickers does the force come from?" My very intermittent experimenting in connection with this phenomenon has shown me that one—or at least I—need not use a twig to obtain a reaction over water, but that a bent piece of copper wire or a piece of lead cable will serve equally well. Also a piece of copper or lead cable will as equally well respond to the presence of metal. Whether there are metals particularly responsive to one another is a matter of research for which I fear I have not the time.

It may seem silly, but it is none the less true, that if I hold a loop of copper wire in my hand, I can appreciate very vividly the linkage (the nature of the bend I do not profess to know) between this wire and the hot water radiator in my room when I bring them close enough together—say, 1ft. apart.

The fact that twigs have broken in my hands (when the wood has been dry), and that the bending of copper wires can be so great as it sometimes is, is to me a source of wonderment and I cannot advance the least theory to account for it. All I know is that it cannot be a personal action (unless it be possible that there are personal actions to which one has no reaction) and the force is only called into play under certain conditions, oft-times not apparent prior to the action, and that the forces called into play are quite large.

In conclusion, I may say that I tried a twig out on my father, brother, and two sisters, they being unaware of my fell design. With father and brother, response was nil; but with both sisters the reaction was strong. One, indeed, threw the twig away in horror as soon as it "wriggled," and although I was somewhat suspect in that quarter as a result, the demonstration proved to me that at least I had not been "kidding" myself.

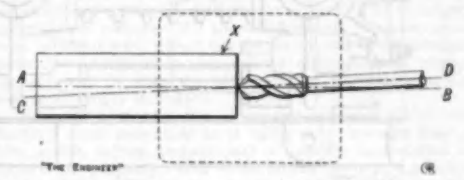
May 30th. F. E. N. (A.R.C.Sc.).

RELATIVITY AND A HOLE!

SIR,—The classical relativity illustration of the apparent difference of path of a stone dropped from a railway carriage window, as observed from the carriage or from the track, has suggested to the writer an interesting paradox connected with the drilling of a hole through a shaft.

Let A B be the axis of a shaft and C D that of a drill, as nearly as possible, but for practical reasons not quite co-axial.

It is, of course, well known that if the drill revolves and the shaft remains stationary, the result will be a hole emerging at C, whereas if the shaft is made to revolve and



the drill is stationary the hole will be true with the axis of the shaft and emerge at A.

Now an observer located on the shaft at X, having no other frame of reference than the drill, can only appreciate the *relative* motion of the drill and shaft, it being entirely immaterial and indeterminate which moves.

How, then, can he account for the different results in the two cases which, unlike the illustration of the path of the stone, which is one of appearance only, is in this case one of actuality?

Any solutions forthcoming would be appreciated at an early date, as the writer is anxious to get on with the job.

R. STANLEY LEWIS.

Ipswich, May 20th.

SIR JAMES JEANS AND THE UNIVERSE.

SIR,—Why, in the controversy in reference to the Jeans' theories, have certain other theories, which are not new, been taken no notice of? Reference to these would, I think, help to clear matters a little. Take a circle, for example, then the longer we make the radius, the flatter does the curve of the circumference become, and when the radius becomes infinite, the curve becomes a straight line, the ends of which meet—or, rather, which has no ends—(contrary to Euclid's definition that the ends of a straight line, if extended to infinity, do not meet), and the infinite straight line encloses an infinite area.

Again, take a sphere and extend the radius to infinity, then the surface of the sphere becomes a boundless flat plane enclosing infinite space!

We cannot picture these facts to ourselves, but that they are facts must be obvious to even the "man in the street" if he possesses even a little mathematical knowledge.

H. R. KEMPE.

Brookham, Surrey, May 30th.

ATMOSPHERIC RAILWAYS.

SIR,—With reference to the recent correspondence on the subject of "Atmospheric Railways," it might be of interest to mention that one of the vehicles used on the Pneumatic Dispatch Company's system of many years ago is exhibited at Bruce Castle (Postal) Museum, Lordship-lane, Tottenham, London, N. 17.

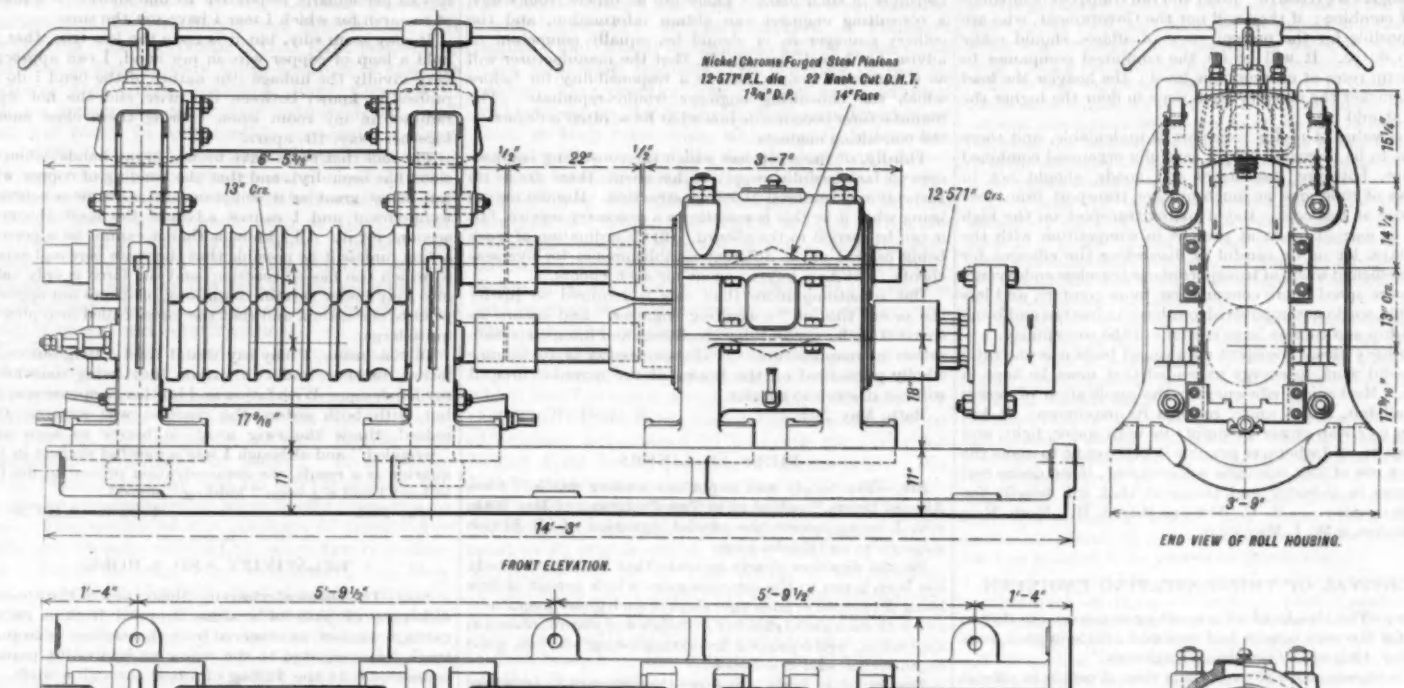
There is also to be seen an illustrated description of the system, extracted from a contemporary text-book on "Pneumatics," by the well-known scientist of that day, Professor Pepper. W. ADAM WOODWARD.

London, May 27th.

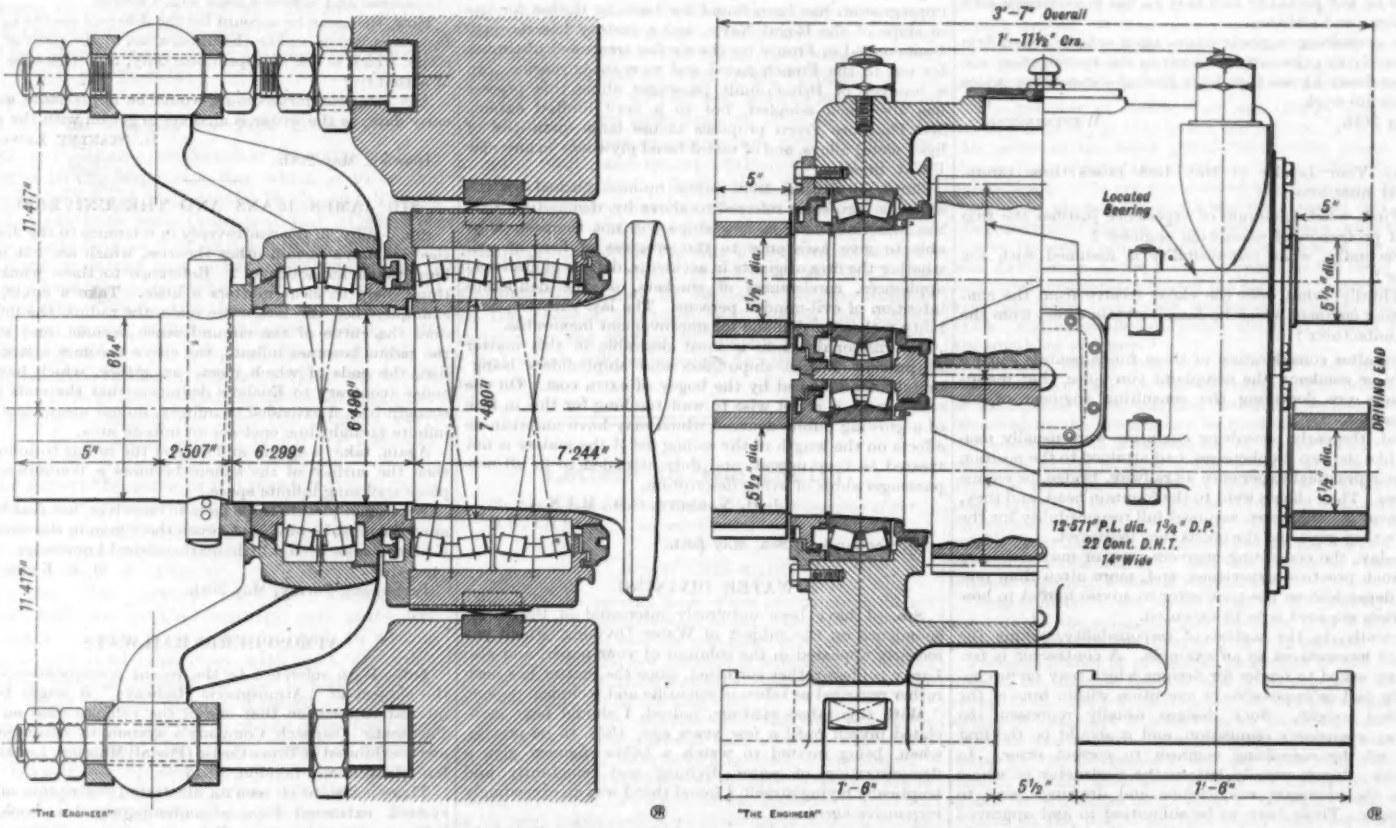
TWELVE-INCH ROD ROLLING MILL

P. R. JACKSON AND CO., LTD., MANCHESTER, ENGINEERS

(For description see opposite page.)



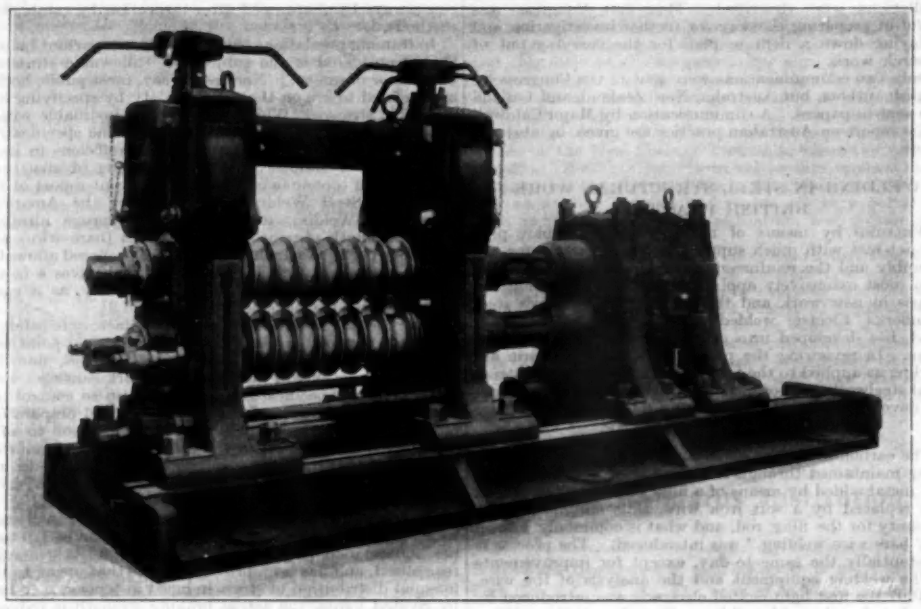
GENERAL ARRANGEMENT OF THE MILL



SKEFKO ROLLER BEARINGS IN ROLL AND PINION HOUSINGS

12in. Rod Rolling Mill with Roller Bearings.

SOME interesting and important developments in the design, construction, and operation of rolling mills have recently been introduced into the works of John Bedford and Sons, Ltd., Sheffield, one of which is the driving of a mill direct by means of an oil engine—probably the only instance of the kind in this country. Another new feature introduced with the object of reducing the cost of production is the adoption of roller bearings. Messrs. Bedford's first application of this kind of bearing was in



ROD ROLLING MILL WITH ROLLER BEARINGS

connection with a 20-ton fly-wheel in 1928, and the saving in power obtained from this conversion prompted an investigation of the possibilities of further economies by the extended use of this type of bearing to other portions of the mill, particularly to the bearings of the rolls themselves. In this connection the extensive experience of the Skefko Ball Bearing Company, Ltd., was utilised, and as a preliminary a series of tests was jointly carried out at Messrs. Bedford's rolling mills with a view to ascertaining the actual loads carried by the bearings while rolling was in progress. We are informed that upwards of 200 such tests under varying conditions were carried out before a selection was made of the bearings suited to the conditions. The data thus obtained enabled the Skefko Company to submit designs for the bearings and housings embodying features already developed in that company's own mills, one of which is the knife-edge suspension system to equalise the load between the two bearings in each common housing. It was found impracticable to utilise the existing stands for this bearing arrangement, and on that account the plant which was working successfully had to be scrapped. Incidentally this step provided an opportunity to introduce certain new features of frame construction to enable the rapid changing of rolls to be effected, and to Mr. N. V. Howard credit is due for valuable suggestions incorporated in the design of the new equipment.

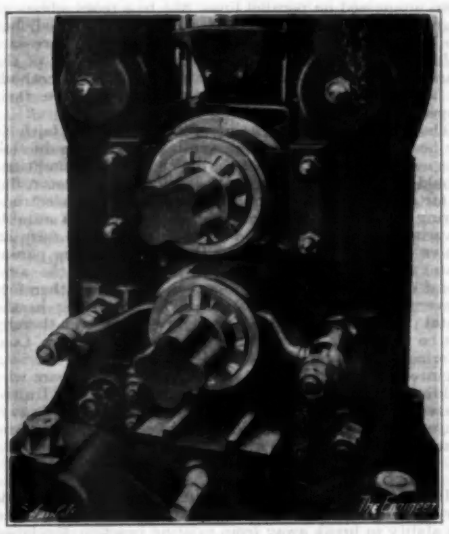
The original intention of the owners was to convert the entire mill, comprising one pinion box and six pairs of roll stands, but before incurring the heavy expenditure which this conversion entailed it was decided to try out the most severe conditions which would be met with, namely, in connection with the cogging operations, in which heavy loading combined with shock and great vertical movement of the top roll have to be accommodated. The design of the stand was entirely new, and to test the practical values of the features incorporated it was decided to run the stand for a reasonable time before proceeding with the conversion of the remainder of the mill. The experience so far obtained has, we understand, justified the enterprise of the owners. By reason of the high quality of the product, namely, metal core hollow drill steel, 0·60 to 0·90 carbon, in 1¼in. to ⅛in. round, square, hexagonal, and octagonal sections, which have to be rolled at temperatures below 900 deg. Cent., the bearing pressures are somewhat higher than usual, actually reaching as much as 80 tons per neck.

On page 618 we present illustrations of the new plant, comprising a new bed-plate, pinion box, and first pair of stands, which have been designed, constructed, and assembled by P. R. Jackson and Co., Ltd., Salford, Manchester, in collaboration with the Skefko Ball Bearing Company, Ltd.

The roll stands are made in cast steel, with loose tops machined and spigotted endwise and crosswise. The tops are secured to the stands by machined stirrups of cast steel provided with cotters in machined cotterways and swivelling on hardened steel bushes recessed into the stands, the arrangement adopted being such as will not weaken the section through the housings. This scheme greatly facilitates the quick removal of the rolls. The rolls have ground necks at each end to accommodate the roller bearings. The bearings which take the journal loads are of the SKF double roller spherical type and are arranged in pairs, pressed close together, and fitted on a common sleeve so that each bearing carries an equal share of the load. These bearings are enclosed in a steel housing provided with seals at each end on the labyrinth principle, thus forming a self-contained unit which adjusts itself to the roll neck with a minimum of resistance.

The end thrust of the rolls in both directions, and also that of the longitudinal adjustment device, is taken up at one end of each roll by an extra roller bearing, which is also mounted in an enclosed steel housing. The pinion housing is of cast iron and is made in three parts, with machined oil-tight joints. Each joint is spigotted crosswise and secured by four fitted bolts, which locate the parts in a direction parallel with the faces of the pinions. The whole housing is secured by four main bolts passing right through the housing and forming it into a totally enclosed unit. An oil bath, oil gauge, drain, and inspection doors are also provided.

The pinions are made of nickel chrome forged steel and have machine-cut continuous double helical teeth which are generated automatically in accordance with modern methods. The necks are ground to accommodate the roller bearings, which are of the same type as those employed in the mill stands, excepting that each neck is provided with one bearing only, the inner ring being mounted direct on the taper neck. The housings are machined to take the outer races of the bearings, and seals are provided at each end. This design of pinion housing lends itself to either splash or force feed lubrication; in this instance splash



END VIEW OF ROLL HOUSING

lubrication has been adopted. The feet of the pinion housing and stands are machined and secured by bolts to a cast iron bed-plate having vee-ways and bolt slots.

CONTRACTORS contemplating road building or other construction work in mountainous territory at high altitude, says the *Canadian Engineer*, should not overlook the fact that petrol engines lose power at the rate of 3·1 per cent. for each 1000ft. above sea level. At 9000ft. above sea level the power loss is about 28 per cent. While power losses due to altitude can be partly compensated for by equipping the engine with special cylinder heads, nevertheless it means that an excavator that has no reserve power at normal levels of operations, cannot be expected to operate satisfactorily at 8000ft. or 9000ft. above sea level. Reserve engine power, it is pointed out, is valuable even at normal levels of operation, but at high altitude it becomes a necessity, if the size of the bucket and, therefore, the handling capacity, is not to be reduced. An excavator that is normally rated 1½ yard, may actually be able to handle only a 1¼ yard bucket, or smaller, at high altitudes. It depends upon how conservatively the manufacturer has rated the machine and its engine power.

British Engineering Standards and Foreign Markets.

A FEW weeks ago the British Chamber of Commerce in Buenos Aires wrote to the British Standards Institution to ask if the lowering of British standards could be considered, as the result of the excellence of material made to those standards was a price that was too high for the South American market. The B.S.I., very properly, circulated the letter amongst manufacturers and representative bodies for their comments. Amongst the replies already sent in is one written by Mr. D. A. Bremner, O.B.E., M.I. Mech. E., Director of the British Engineers' Association. We have Mr. Bremner's permission and the consent of the B.S.I. to make use of this memorandum, and have much pleasure in presenting long extracts from it below. The matter is one that merits the attention of all engineers. We make some further comments upon it in our leader pages this week.

British machinery has to be sold in the home market, the Empire markets, and foreign markets. According to the latest available figures our total output of machinery has been absorbed by the home market to the extent of about two-thirds, and the remaining third exported has been approximately equally divided between Empire markets and foreign markets. The great economic importance of increasing our export trade in highly manufactured articles is fully realised to-day, and it is therefore necessary that it should not be restricted by lack of adaptability to the requirements of the different markets, or by costs of production and distributon causing these goods to be offered at non-competitive prices.

Broadly speaking, British standards and British practice have been such that the quality of our machinery has commended it to the purchasers in every country who were able and willing to pay the price. In other words, our machinery has seldom, if ever, been excluded from a market because of inferior quality, though, perhaps, in conception and design it may sometimes have been outclassed by highly developed specialised foreign products. In these circumstances, we are faced with the difficult problem of satisfying diverse conditions, whilst retaining the greatest possible measure of standardisation and uniformity of product, in order to secure the benefits of economic production. Obviously, the solution of the problem will be in the nature of a compromise.

British engineering standardisation and practice, as they stand to-day, are the product of our native genius, long experience, and the complex interplay of legal and political forces directed chiefly to securing the safety of the workers and the public, the preservation of the amenities of urban life and the safeguarding of the rights of property owners. All these influences, in some degree and in some way, affect our factory costs of production, sometimes favourably, but mostly unfavourably, though it may well be that the total cost to the nation is not correspondingly increased.

National cost, however, is a very different thing from factory cost, inasmuch as it takes into account loss of life, bodily injury, impairment of health, destruction or injury of property, and breakdowns of transportation and public utility services. Moreover, machinery and other manufactured goods are sold, not on the basis of national cost, but on their factory production and distribution costs.

The dominant fact is that the British machinery manufacturer, in producing and selling his products in the home market, has to satisfy conditions differing from those imposed upon his foreign competitor, and from those accepted by the purchaser and the user in most of our export markets. Unfortunately for us, laxer conditions in other countries usually operate to our disadvantage owing to the British machinery manufacturer having to produce about two-thirds of his output to suit the more exacting requirements, laws, regulations, standards and quality expectations of the home market.

Although, to some extent the purchaser of British machinery has a choice of quality and price, the fact remains that a given British machine of the grade or class to which it purports to belong is often superior to and dearer than the machine offered against it by a foreign manufacturer.

From the point of view of economical manufacture and distribution, there are obvious serious objections to the production, at the same factory, of different qualities of the same kind of machine to suit different markets. It is no exaggeration to say that high-grade and low-grade machines, of the same kind and for the same general purpose, cannot be manufactured commercially in the same works and by the *personnel* of the same organisation. Machines made to special order, in the same works, in accordance with different purchasers' specifications, may and do differ in quality in terms of design, materials, and workmanship, but only within moderate limits, and engineering works with a reputation for high-class products will seldom if ever undertake to make a substantially inferior article, likely to do them discredit.

The deliberate, planned manufacture of inferior and cheaper grades of machinery for export would, therefore, have to be carried on at separate works, by concerns established and organised for that class of trade, and their products being below the British Standard, would find little sale in the home market.

There are only limited possibilities of educating the foreign buyer to accept our views, to admit the superiority of British machinery, and to pay for it on the ground that in the long run it will prove to be the more profitable investment.

The claim that British engineering standards, British engineering practice and the resulting quality of British machinery are "superior" to those of our competitors should be re-examined critically and honestly, in the light of the knowledge and experience of to-day, without burking the pertinent question as to whether we are always in the right and our competitors are always in the wrong.

Machinery, made in accordance with standards and practice differing from our own, is doing the greater

part of the world's work to-day. For all practical purposes, much of it is as good as ours, and some of it is even superior in some respects to its British counterpart.

Unnecessarily high factors of safety result in increased costs of production and distribution, uncompensated by any advantage of monetary value, and are therefore a symptom of bad engineering. Progress in metallurgy and the chemical and physical control of metallurigcal operations, in the science of design, in the development and refinement of processes of production and construction, in gauging and in testing, would appear to make it only reasonable that factors of safety should be reviewed and, if necessary, revised at reasonable intervals of time.

Nevertheless, the British reputation for "quality" is a laboriously created asset which we can ill afford to depreciate, far less destroy. It is more than doubtful whether it would be an economic possibility to maintain anything like our standard of living, on the manufacture of articles of a quality which any and every competitor could supply. In fact, it is practically certain that our real wages and our standard of living would soon be depressed to the general level.

In these circumstances it is clear that any actual degradation of our standards and practice resulting in a real debasement of British machinery might be suicidal. But it is of vital importance to distinguish between what is actual or real and what is only apparent or illusory. Improvements in design, better judgment in the selection of materials, the reduction of extravagant factors of safety and weights, may result in economies without any sacrifice of true quality of product. On the contrary, they may enhance it and be the expression of a higher standard of engineering.

Bridge and Structural Engineering Congress.

EIGHTEEN months ago there was formed at Zürich an International Association for Bridge and Structural Engineering, the object of which was to encourage an exchange of ideas on the practice and theory of design and construction, and to publish the results of research and experiment in structural work of all kinds. That organisation held its first Congress in Paris last week at the headquarters of the Société des Ingénieurs Civils. There was a large attendance of members from many parts of the Continent, and Great Britain was officially represented by a delegation led by Professor Sir Thomas Hudson Beare, of the University of Edinburgh, and composed of Professor R. V. Southwell, of the University of Oxford; Mr. C. S. Chettoe, of the Ministry of Transport; Mr. J. W. Spiller, one of the chief engineers to the Crown Agents for the Colonies; and Mr. R. F. Maitland, secretary of the Institution of Structural Engineers. The first publication which has just been issued by the Association contains twenty-six reports, mainly in German, with French translations, as well as French communications and a few in English. The reports were briefly summarised at the meetings, and there was no general discussion upon them, this being replaced by communications by members who had previously announced their intention of making them. A second publication will be issued eventually containing all these supplementary communications, as well as anything else dealing with the subjects presented at the Congress. These subjects were classed under the heads: Stability and strength of structural members subjected to compression and bending; Slabs in reinforced concrete structures; Welding in steel structural work: Large girder bridges in reinforced concrete; the Dynamics of bridges; Development of the statics of reinforced concrete; Girders in conjunction with concrete; and Research concerning building ground. The welding of steel structures was dealt with extensively. It would appear that whilst there is not much difference in cost as compared with riveting, the gain in weight is appreciable, and this offers a distinct advantage in bridge building. The longest welded bridge was said to be a road bridge at Pizen, in Czechoslovakia, which has a length of 161ft. 5in. In view of the increasing importance of electric welding it was suggested that mill-owners should roll sections specially suited for economical welding.

In the construction of reinforced concrete bridges the Germans have moved with great caution, and they first established experimental data which are now accepted as the basis of calculation for such structures. The French worked out their own theories, generally with complete success, and the longest spans of nearly 135 m. for girder bridges and 200 m. for arches are to be found in France, notably the footbridge across the Seine at Ivry, which is of rectangular section with six compartments to carry electric cables, the rue Lafayette bridge in Paris, and the Plougastel bridge near Brest. There is also a difference in the methods adopted by the French and others in obtaining a "continuity of reinforcement"—that is to say, in continuing the metallic reinforcement throughout. The French depend more largely upon the strength of the concrete, while the Germans and others carry the metallic reinforcement continuously by using turnbuckles or welding the rods. There is no uniformity of methods, and reinforced concrete is suffering some reaction, partly because of an absence of definite principles and partly on account of the crisis in the steel industry, which has lowered prices and has encouraged a more active propaganda in favour of the employment of steel. While the Bridge and Structural Engineering Congress was in progress an International Congress of Offices for the Utilisation of Steel comprising groups from ten different countries, was also sitting.

This was the first meeting of its kind, and the second Congress will be held in Düsseldorf next year. There is a tendency in France to use steel more extensively for structural work, and in Paris there were nearly six times the number of steel-frame buildings under construction last year as compared with 1928, when reinforced concrete reached its highest point of popularity. In bridge building spans can only be increased by means of a continuous metallic construction, and examples of girder bridges in concrete were illustrated by Dr. Ing. Santarella, Professor at the Ecole Polytechnique at Milan. The amount of metal used in their construction is less than in the all-metallic structures, and there is claimed to be an economy in total cost, while the concrete protects the steel and gives to the whole a greater rigidity. It may be recalled that the steel star-shaped bridge outside the Gare St.-Lazare in Paris is encased in concrete, but that is done solely to protect the metal, without any particular object of increasing rigidity and strength. It was stated that reinforced concrete bridges were constructed in Hungary before 1890, and that such a bridge was built across the river Nyita, near Ersekujvar in 1892.

Much attention was given at the Congress to bridge dynamics, which, it was said, could not be based upon theoretical considerations alone, and that the theory would have to be developed by systematic practical experiments carried out in accordance with a scientific plan. There were several papers on this subject, as well as on the theory of oscillations, and apparatus for recording oscillations were described. This first Congress was useful in preparing the way for further investigation and in laying down a definite plan for the carrying out of research work.

Only two communications were sent to the Congress by English authors, but Australia, New Zealand, and Canada also sent in papers. A communication by Major Caldwell and a report on Australian practice are given in abstract below.

WELDING IN STEEL STRUCTURAL WORK: BRITISH PRACTICE.

WELDING by means of the oxy-acetylene blow-pipe has not met with much support in Great Britain for the assembly and the reinforcement of steel bridges, but has been most extensively applied to the purpose of cutting shapes in new work and the removal of defective steel members. Electric welded construction, on the other hand, has developed into general practice during recent years. In reviewing the present position of electric arc welding as applied to the fabrication and erection of structural steelwork, it is of interest to recall the early steps in the development of the process and its application.

HISTORICAL PROGRESS.

The carbon arc process was introduced in 1885, the arc being maintained through the medium of a carbon pencil and metal added by means of a filler rod. In 1890 carbon was replaced by a soft iron wire, thus eliminating the necessity for the filler rod, and what is commonly known as "bare-wire welding" was introduced. The process is substantially the same to-day, except for improvements in the welding equipment and the analysis of the wire. In 1907 the first light-coated electrode was introduced by covering the wire with a thin coating of paste, in order to stabilise the arc. A close study was made at that time of the metallurgical side of the problem, and in 1911 the first heavy-coated electrode was produced in Great Britain. As confidence in the process grew, the welding of steel structures became a practical proposition. British welding engineers, faced with conservatism and unfavourable regulations in their own country, were forced to go further afield to introduce their ideas. The results and progress of their initial pioneering have been particularly marked in Belgium, Switzerland, and Australia, and their work throughout has been based on the application of the heavy-coated electrode. In America, welding engineers have progressed on parallel lines, and to a more advanced degree in the quantity of welded steelwork erected, but the bulk of their work has been carried out with bare wire welding. The differentiation is important in view of the marked variation in characteristics of design and methods of fabrication produced by the two processes in their respective spheres.

The British welding engineer, in pinning his faith to the heavy-coated electrode, maintains that the production of a metallurgically sound weld under practical conditions should not depend entirely on the skill of the operator, but as far as possible on the natural function of the electrode during fusion. In other words, he considers that a suitable covering should be provided on the electrode to form an active slag that will (1) clean the surface of the parent plates from oxide during welding; (2) protect the weld metal whilst molten from atmospheric gases and therefore prevent oxide and nitride defects from forming in the metal; and (3) melt at a low temperature and thereby not be trapped in the weld metal as slag inclusions. Considering the extensive practical experience of American engineers in the erection of steel structures with bare wire welding, the marked tendency apparent in the United States during the last eighteen months to employ heavy-coated electrodes provides some justification for the claim that European engineers are sound in this connection.

DESIGN.

It is certain that success in welding construction depends very largely on the initiative shown by the designer and his ability to break away from existing practice developed essentially for riveting. Bare wire welded structures of the open truss type, with their general use of the simple lapped joint and rolled steel sections, do not appear to differ very largely in form from riveted structures. On the other hand, in Europe there is a more advanced tendency to design welded structures on a monolithic basis, with a general use of butt-welded joints, even in main members.

A further characteristic of considerable importance, and individual to structures welded with heavy-coated electrodes, is the general application of light single-run fillet welds. This practice, although of comparatively recent introduction, has been successfully developed to an advanced degree both in Switzerland and Australia. The linear strength of a fillet weld is approximately proportional to the square root of the linear volume of weld metal deposited, so that the economic advantages of the light single-run fillet weld are paramount. A further asset is that welding contractional stresses are reduced to a minimum, but what may perhaps be regarded as the most important advantage is the fact that the soundness of a weld can be judged by expert visual inspection, provided that correctly constituted heavy-coated electrodes are applied. Thus the problem of control and inspection is solved in a simple, economical, and efficient manner.

BUILDING REGULATIONS AND INVESTIGATIONS.

One of the most important developments in welded structural steelwork in recent years is the movement on the part of public bodies to draft regulations for its control. Under the usual forms of building regulations, no methods may be used which are not definitely sanctioned with appropriate specifications and provisions for inspection. Therefore the essential first step is to get welding recognised, naturally with safeguards for its proper execution. Welding committees have been formed in many parts of the world, and their research engineers are submitting welded construction to a more exacting scrutiny in many respects than has ever been made of riveted construction in the past. It may be suggested that more is now known of the behaviour of welded joints than concerning the behaviour of riveted joints. There have been cases of the failure of riveted joints which have passed the scrutiny of boiler insurance inspectors and hydraulic tests, traceable to the faulty manipulation of hydraulic riveters. Hence it is inaccurate to say that riveted joints can always be guaranteed after inspection by established methods.

In framing regulations one of the most important factors to be considered is the subject of "allowable stresses" or "factor of safety." Needless to say, most public bodies are inclined to err on the side of safety by specifying low allowable stresses. Whilst this is quite justifiable within reason, it should be borne in mind that the specification of a too high factor of safety is quite sufficient in itself to prohibit or seriously limit the welding of structural steelwork on economic grounds. The recent report of the Structural Steel Welding Committee of the American Bureau of Welding states that the average ultimate tensile strength obtained on butt welds (bare wire) was 22·1 tons per square inch, on which the proposed allowable working stress of 5·8 tons per square inch gives a factor of 3·81, which it assumes to be satisfactory, as it compares with the normal steelwork factor of 3½.

The generally accepted purpose of a "factory of safety" is to keep the load stresses well below the yield point and to allow a margin for indeterminate stresses, and for practical variations in materials and workmanship. Provided suitable specifications are drawn up to control the ability of the operator, electrodes, design and preparation of material, &c., there would appear little reason to anticipate greater variation in the quality and workmanship in welding than riveting. In other words, it would not appear unreasonable to assume practically the same factor for welding as for riveting or the steel itself.

In Great Britain for a 28/30 tons per square inch steel we have an allowable working stress in tension of 8·0 tons per square inch (*i.e.*, a factor of 3·5). It is generally recognised, and has been proved by test, that owing to the unequal distribution of stress induced in tension members by riveted joints, the actual braking strength is reduced by 20 per cent. so that the effective factor of safety is 2·8 and not 3·5. In compression the allowable working stress is 6·5 tons per square inch, which, when compared with the yield strength of the steel, 18·0 tons per square inch (the point of failure in compression), shows a factor of safety of 2·77, which is roughly the same as that for tension. These calculations assume that the shearing strength of the rivets bears a definite relation to the tensile strength of the parts joined. Often it is assumed that the two are equal. This strength does not come into full play unless all the rivets are equally good fits in their holes. The 20 per cent. reduction is meant to allow for possible departure from the condition; it may sometimes be insufficient. Under these circumstances a factor for welding equal to that for the steel, or at the most 4·0, would appear to be ample.

In published results of recent investigations it would appear that much importance is attached to the determination of the static strengths of welded joints. Such values are of secondary importance, except for use in design. Factors that deserve more attention are the resistance of welded joints to dynamic stresses, corrosion, solidity, and ductility in the weld metal and, above all "consistency under practical conditions." The future of welded steelwork must depend to a very large extent on its consistency under practical working conditions; in other words, on its reliability. The main factors controlling economic and consistent welded production include intelligent design, sound organisation, and welding procedure, thoroughly trained operators and inspectors, and the employment of correct welding equipment and electrodes. These factors would appear to present much more fruitful fields for investigation and subsequent control than the physical properties of various types of welds, which are meaningless, unless they forecast with a reasonable degree of accuracy the results that one may expect to obtain in practice.

STRENGTHENING OF STEEL STRUCTURES BY WELDING.

The application of electric welding to the strengthening of steel structures has offered a valuable solution to railway and municipal engineers faced with the problem of coping with increased traffic loads and depreciation due to corrosion. Well over 100 bridges have been strengthened by welding on Australian railways, and quite a considerable amount of important work has been carried out in Great Britain. Similar operations are either in progress or contemplated in India, South Africa, and certain of the Crown Colonies. The main advantages claimed for the application of electric welding to the strengthening of bridges are briefly:—(1) In some cases the only alternative to strengthening by welding is complete renewal; (2) cost is invariably much less than when other methods of reinforcement are employed; (3) delays to traffic passing over the bridges are avoided or greatly reduced; (4) in most cases underpinning or staging is unnecessary, and on principle the existing structure is not weakened or disturbed by the replacement of members and rivets in the initial stages, as is often the case with alternative methods.

The strengthening of structures by welding may be divided into three broad classes:—(1) The reinforcement of riveting or riveted joints in which the welding and riveting act conjointly in carrying the stresses, as in the strengthening of lattice girder connections or plate girder flange angle and web splice riveting; (2) the reinforcement of existing members by welding on additional plates or sections; (3) the strengthening of girders by increasing their depth or by adding new members, such as extra ties, struts, or cross girders, &c.

COMBINATION OF RIVETED AND WELDED CONSTRUCTION.

The question is sometimes raised as to how riveting and welding act in conjunction with each other, or, in other

words, "What is the strength of a riveted and welded joint?" It is quite possible for a riveted connection to be reinforced by welding, and for the welding to bear the whole of the load and fracture before the riveting comes into play, because of the presence of "slip" in the rivets. In the case of an existing bridge, however, it must be borne in mind that the members are already bearing their dead load before the welding is applied, and, furthermore, it would appear safe to assume that the initial slip in the riveted joints has already been taken up, owing to the continual variation in the stresses transmitted and the natural vibration of the structure. It has been found that the strength of a combined welded and riveted joint may be estimated as the ultimate strength of the welding plus the yield point strength of the riveting. In strengthening lattice girder joints it is necessary to ensure that the additional stresses carried by the welding are transmitted across the joint to the member on either side; that is to say, clear of the sections that are weakened by the existing rivet holes, and this may entail the use of extra gusset plates.

NOTES ON ARC WELDING IN BRIDGEWORK IN AUSTRALIA.

A summary of the railway and highway bridges repaired or constructed by arc welding in Australia shows that this process has been introduced into 136 bridges to date, excluding footbridges and small bridges for industrial tracks.

REPAIR OF RAILWAY BRIDGES.

The main applications in repair work have been:—

(1) Relief of rivet stresses. Flange rivets in plate girders relieved by welding flanges to webs. Rivets in end connections relieved by welding existing gussets and adding new gussets where required.

(2) The addition of extra section to flanges of plate girders and truss members.

(3) The stiffening of members as long columns.

(4) The correction of minor faulty details.

(5) The repair of wastage of section caused by corrosion.

The advantages found as compared with the older methods were:—Less cost; less interference to traffic, as in nearly every case the extra sections could be added without interference to any existing work; greater facility for making good any defects caused by corrosion, and for providing weather welding to prevent further corrosion between sections in contact; greater facility for correcting faulty design, such as ineffective or eccentric connections; less danger of loosening adjoining rivets.

NEW RAILWAY BRIDGES.

Welding on new railway bridges has not proceeded far, being limited up to the present to joist or broad flange beam spans, but in these alone considerable savings have been realised over the older riveted and field bolted or field riveted designs. In the case of small rolled steel joist bridges, the common practice was to field bolt crossheads, bracing, &c., and the maintenance of these bolted joints has now been eliminated. Enough work has now been done to furnish satisfactory proof of the safety of the process, even with the mild steel electrode, and the introduction of better electrodes will in future allow greater freedom of design, both in details of joints and in span lengths.

HIGHWAY BRIDGES.

The development in highway bridges has advanced further than in railway bridges. As well as major reconstructions of spans up to 150ft., with a strengthening of as much as 50 per cent. of the main girders, the development of new work has proceeded limited only by the small scope for bridgework in Victoria. There have been only four steel highway bridges erected in that State in the past three years, and all are wholly welded.

The first example was Pyke's Creek Bridge, where welded trusses formed the reinforcement of a concrete bridge. The low cost of these trusses led to the next design being entirely steel, and Sunday Creek Bridge was designed with "N" type deck trusses, with spans of 52ft., 65ft., and 52ft. Both these bridges were easy of access and the welded trusses were shop fabricated in sections.

The next truss design was that of the Snowy River Bridge, continuous Warren deck trusses, one span 100ft., four spans 135ft., one span 100ft. This bridge being in a remote site with difficult access by an old mining track, the steel was sent direct from the mill to the site. The design was arranged so that mill lengths could be used, and hardly any oxy-cutting was required, and no service bolting whatever. The facility for welding overhead and vertically with properly designed electrodes enabled the trusses to be fabricated complete on the flat without turning over or moving until erection. The weights of corresponding riveted and welded designs were 173 tons and 133 tons respectively, the welded work thus giving a saving of 23 per cent. in weight, and in this particular case nearly 30 per cent. in cost.

The Tambo River Bridge consists of cantilever plate girder spans, 61ft. 8in. and 62ft. 2in., the anchor girders being 76ft. 3½in. long and the suspended spans 33ft. 11½in. The design was originally based on the use of broad flange beams, but the tariff and adverse exchange rendered a built-up girder more advantageous. The comparative weights were:—

Broad flange beams, 160 tons.
Riveted plate girders, 116 tons.
Welded plate girders, 101 tons.

Although the advantage in cost of the last type was only small, the Board preferred the welded work, having regard to subsequent maintenance and life of the structure.

ELECTRODES.

From the outset almost all this work has been carried out with covered electrodes of the "mild steel" type, and the adoption in the first place of the covered electrode was undoubtedly a contributing factor in the rapid extension of the work. Since 1929, electrodes, British and Australian, of the alloy type, introducing a higher percentage of manganese or nickel, have been used in a few instances. For Victoria-street Bridge, an electrode depositing a manganese-chromium alloy is being employed. These newer electrodes should remove all remaining doubts as to the advisability of adopting welding in bridge construction, the properties of the weld metal being less variable than those of rolled mild steel and of the same order of quality and actually superior in some respects, such as resistance to shock.

CONCLUSION.

As regards reliability, it should be noted that only one failure has occurred with welding carried out by the proper covered mild steel electrode, and this failure can be definitely attributed to design rather than workmanship. The welding in this case was in a handrail, and was subject to very high alternating bending stresses, owing to the rigidity of the welded hand rail not having been foreseen, and the hand rail actually acting as a deep truss. This failure, however, served to indicate the desirability for the improved alloy steel electrode, in place of the mild steel electrode depositing practically pure iron, particularly for important bridge work, subject to severe stressing.

The work has been diverse in type and has been carried out under a wide range of conditions from extremes of heat in the centre of the Continent to extremes of wet climate on the West Coast of Tasmania, where the annual rainfall is 120in. In fact, it would be safe to state that the more adverse the conditions, the greater the advantage, as welding supplies and plants are very portable, allow great facilities for improvisation, and reduce the *personnel* required.

Most important of all is the established fact that the iron or steel bridge has now the possibility of a greatly increased life, as reconstruction to overtake deterioration or complete remodelling to meet change of requirements can be undertaken, as instanced in the cases of Hawthorn and Victoria bridges. This process therefore counters to some extent the advantage of greater permanency claimed for the reinforced concrete bridge, and gives the steel bridge a greater flexibility as regards alteration to meet changing conditions in the future.

British Standards Institution.

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria-street, London, S.W. 1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

THE FUSION TEMPERATURE OF COAL ASH.

No. 453—1932. It is well known that the ash present in coal may be objectionable for furnace purposes, not only on the score of the amount present, but because of its relative fusibility and liability to clinker. Generally speaking, there is some connection between the fusion point of the coal ash and the tendency to clinker, but there are few reliable data establishing the relation between the laboratory test and the furnace. In this specification the correlation of the fusion temperature of coal ash with practical furnace conditions is attempted. The method consists in observing, by means of an optical pyrometer, the temperature at which deformation occurs on heating triangular pyramids commonly described (in this connection) as cones. A button may also be used for this purpose, but observation of the fusion point may be more difficult than with the cone. A suitable size of button is ¼in. in diameter and ¼in. high. The method allows the determination of fusion temperature to be made in either an oxidising or a reducing atmosphere, the result, in the latter case being invariably the lower if the ash contains iron. The determination should normally be carried out in a reducing atmosphere, but in all cases the nature of the atmosphere shall be reported. Under furnace conditions, the temperature at which a coal ash will fuse to form clinker is not necessarily so low as that determined in a reducing atmosphere, but will depend upon the atmosphere in the fire-box or furnace and the conditions of firing.

MACHINE-CUT GEARS.

No. 436—1932.—The question of the standardisation of gearing has received a good deal of attention during recent years, not only in this country, but also abroad. Progress has been made in other countries with regard to the dimensions and tooth form of helical gearing, but the new British Standard Specification, just issued, for Machine-cut Helical and Straight Spur Gearing deals with the question in a more comprehensive manner than has hitherto been attempted.

The specification contains a large amount of information on the design and strength of industrial gears, and the matter is presented in such a form as to be immediately available for the design of gears and the solution of gear problems. Hitherto reliance has had to be placed on one or other of several formulæ, and on this account it has not been possible to apply any simple and reliable system of checking such as can be applied with certainty in other branches of engineering. Another practical point to which attention has been given is that of intermittent rating of gears which, in normal operation, are subjected to varying loads, overloads, and periods of rest.

The specification deals with machine-cut gears connecting parallel shafts, the teeth being either straight, single, or double helical, and of the 20 deg. full depth involute system (with a working height of twice the module) of the following classes:—

Class A.—Precision ground or cut gears suitable for peripheral speeds exceeding 2000ft. per minute.

Class B.—High-class cut gears suitable for peripheral speeds between 750ft. and 3000ft. per minute.

Class C.—Commercial cut gears suitable for peripheral speeds below 1200ft. per minute.

In addition to dealing with the form of gear teeth, clearance, maximum permissible pitch errors and tolerances, the specification lays down standard formulæ for the strength and rating of gears and includes a series of charts showing at a glance the proportions of gear wheels of different materials.

Although it is recognised that stub tooth gearing and gearing with a pressure angle of 14½ deg. have been used with success for many years and will for many purposes continue to be used, the Committee, after careful consideration, realising the importance to the trade of the country of the establishment of a single standard for general application, has recommended a pressure angle of 20 deg. The standard 20 deg. pressure angle tooth possesses the desirable qualities of strength and ability to withstand wear and, at the same time, is equal to other forms as regards quietness of running. Compared with the 14½ deg. pressure angle, the strength at the root is considerably greater and undercutting in gears having small numbers of teeth is not so pronounced. Compared with the 20 deg. stub tooth it is approximately equal in strength, and has the advantage as regards wearing properties, in having a longer arc of contact. Although the arc of contact is a little shorter as compared with the 14½ deg. pressure angle, the relative radius of curvature of the tooth faces is greater, which more than compensates for the reduction in the length of the arc of contact.

The new specification requires the shape of the space at the root of the tooth to be approximately semi-circular, as tests have shown that, although the increased depth due to the semi-circular clearance space reduces the static strength, it greatly increases the resistance to fatigue of hardened and other heat-treated gears.

The next section of the Gearing Specifications to be taken in hand will be that dealing with bevel and spiral gearing.

The price of this specification is 5s., 5s. 6d. post free.

BRITISH STANDARD SCREWS.

No. 450 and 451—1932.—These specifications provide for round, countersunk, and cheese-head screws from ¼in. diameter up to 1in., and square-head set screws from ¼in. up to 1in., and give the dimensions of the screws generally.

SIXTY YEARS AGO.

PATHETIC interest attaches to an article entitled "On Designing Wrought Iron Girders," which appeared in our issue of June 7th, 1872. The article was the reprint of a paper read before the Edinburgh and Leith Engineers' Society. Its author, Mr. Alan D. Stewart, was jointly responsible with Mr. Thomas Bouch for the design of the first Tay Bridge, then in course of construction. Mr. Stewart had much to say concerning current bridge-building practice, but it is abundantly evident that his own knowledge of the subject, like that of his contemporaries, was largely governed by arbitrary rules and by traditionary principles. The fall of the bridge during a storm on the night of December 28th, 1879, was required to shake the faith of engineers in those rules and principles. We of a later and—so far as bridge designing is concerned—a wiser generation should be just to the memory of Mr. Bouch and Mr. Stewart, and not blame them for failing to be in advance of their times. Yet having said so, we must still wonder why the Tay Bridge failed as it did. It was certainly the world's longest bridge at the time it was built, but apart from that fact there was nothing exceptional about it. It had a length of 3760 yards and consisted of 114 spans, varying from 30ft. to 200ft. The girders were of wrought iron lattice work, and in some cases were continuous over the piers. The longest of the continuous girders measured 800ft., and covered four 200ft. spans. Mr. Stewart's paper shows that the two questions which gave him and Mr. Bouch chief concern were the ratio of the height of the girder to the span and the form of the bracing. The ratio of the height to the span was settled at one-eighth, a figure, it may be noticed, which current practice assigned as about the maximum to be adopted in iron girders of the open web type. As for the bracing, it was decided to make it in the form of "a series of single crosses," the diagonals intersecting each other at right angles. Mr. Stewart was critical of the use made in some recent bridges of multiple cross bracing, one reason being that with such bracing the wind force on the side of the bridge was much greater than with single cross bracing. It is possible that the theory of continuous girders was not very completely understood in those days, that the properties of iron as a bridge-building material were not fully known, that the pressure which wind could exert on a bridge was greatly underestimated, and that the scientific analysis of stresses in structures was not a familiar study. In any one of these factors, or in a combination of them, the cause of the collapse of 3000ft. of the Tay Bridge may be found. Accompanying them there were no doubt many minor factors introduced by the designers' desire to construct an economical bridge. The contract price was only £217,000, or just over £19 per foot run.

SLOGANS.

IN my experience of running factories, I have always found it of great assistance to give people something to aim at which is a little better than what is now being done. The aim should be to fix a standard output or goal sufficiently high that it requires striving to reach, and yet not so high as to make it incapable of attainment. We, therefore, after careful examination, set our standards in order to focus the activities along predetermined directions. For example, in locomotive practice last year we set ourselves the standard of "100,000 miles between general repairs." We did not reach it, but we increased our mileage between general repairs from 50,000 to about 60,000. Now had we simply said we must get greater mileage between locomotive repairs we should have had different people giving different standards, and all efforts would not have been directed towards our ideal for 1931 of 100,000 miles. This year (1932) we hope to reach that standard; people may scoff at slogans, if this may be regarded as a slogan, but I can assure them that they are powerful instruments for getting things done.—*Mr. E. J. H. Lemon, at the Inst. of Transport, Buxton, June 1st.*

A New Photo-Print Developing Machine.

WE have just examined a new type of photo-print developing machine, for drawing-office and similar work, which seems to have several merits. It is being made by Precision Photo Printing Plant, Ltd., of Salisbury House, E.C. 2, and its general appearance can be gathered from the accompanying engravings, while some of the details of its construction are shown in the drawing.

The apparatus is intended essentially for developing positive prints of the Ozalid type, which need exposure to ammonia fumes for their completion and produce a deep red design on a white background.

In the past the development of such prints has caused some inconvenience on account of the escapement of ammonia fumes into the surrounding atmosphere, while the humidity of the paper and gas, in association, has sometimes caused difficulty through a too humid atmosphere producing blurred outlines. We have assured ourselves, however, that exposures can be passed through the

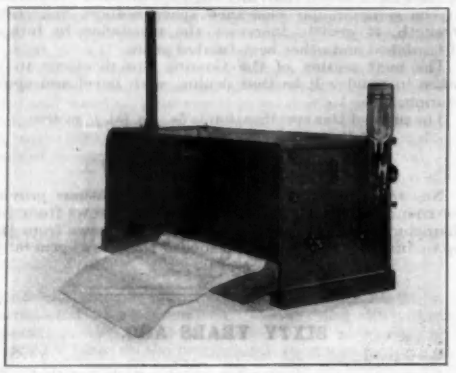


PHOTO-PRINT DEVELOPING MACHINE

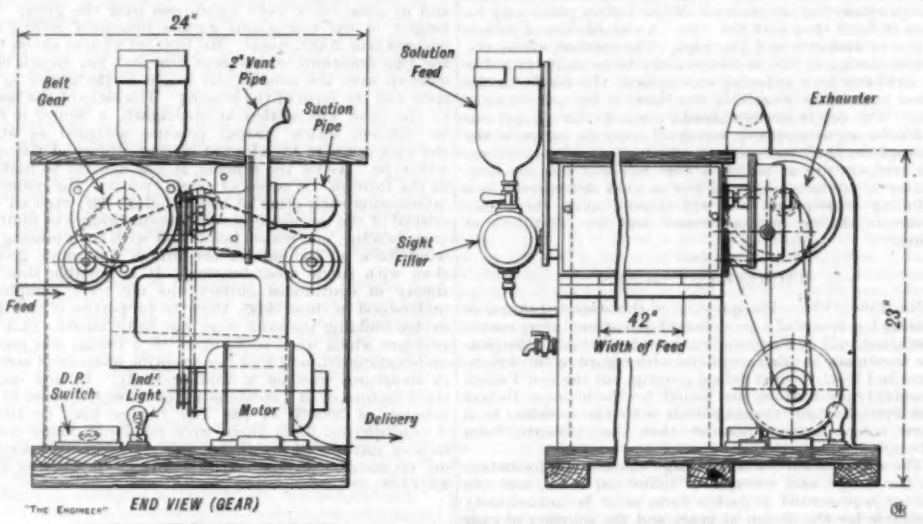
machine under review without any appreciable fear of either of these objections.

In the first case we discovered no odour of ammonia that could be considered offensive during the operation of the machine; but, to confirm this impression, we set a number of pieces of moist red litmus paper about the machine. Those which were put on the delivery table certainly did become stained with blue, but the others remained red, a conclusive evidence that free ammonia was not escaping from the machine.

The effect is produced by the simple expedient of providing a fan for drawing away from the outlet where the developed print emerges such gas as has not been absorbed. This gas is led away to the outside air by the duct which can be plainly seen towards the left of the half-tone engraving.

The matter of the humidity of the developing gases and its effect on the results of the process has been overcome by a combination of electrical heating units. The ammonia gas is, naturally, evolved by the evaporation of a commercial solution of NH_3 (0·88), which is diluted to the extent of about 50 per cent. with water. This liquid is supplied to the machine from an ordinary Winchester quart bottle, inverted, and is admitted, as occasion requires, through one of those little instruments known to whisky drinkers as an "Optic." That is to say, at each operation of the "Optic" a small measured quantity of ammonia solution is passed into the machine. It flows on to a tray in the bottom of what looks very much like a muffle furnace and is there evaporated by the heat of an electrical resistance. The top of the chamber is domed, as can be seen in the drawing, and is perforated. Other heaters are so arranged that the fumes produced shall be of the proper temperature and humidity. The dome is made of Monel metal. The print to be developed is drawn over this surface by a rubber band which is stretched over three pulleys, and in its passage is exposed to the fumes coming through the perforations of the dome. There is no further preparation of the print necessary.

The machine is substantially made, an engineering proposition, and only requires ¼ horse-power for driving both the fan and the rolls for paper up to a width of 42in. The speed of feed may be as great as 6ft. per minute.



SECTIONAL VIEWS OF PHOTO-PRINT DEVELOPING MACHINE

L.M.S. RAILWAY PLOUGH BRAKE VAN

CRAVENS RAILWAY CARRIAGE AND WAGON CO., LTD., SHEFFIELD, ENGINEERS

Mechanisation of Permanent Way Maintenance.

IN connection with the mechanisation of permanent way maintenance, the London, Midland and Scottish Railway has placed in service some new 25-ton hopper ballast wagons, of which 108 will ultimately be provided, operating in conjunction with nine plough brake vans, each of which will normally work with a train of twelve hopper ballast wagons. Ballast trains composed of these wagons and plough brake vans are being run from the principal ballast-quarry centres throughout the L.M.S. system conveying up to 300 tons of ballast per train, and some remarkable performances in expeditious loading and discharging of ballast have already been recorded.

The wagons, which have a capacity of 25 tons, have been constructed for the L.M.S. Ry. by the Metropolitan-Cammell Carriage Wagon and Finance Company, Ltd., of Birmingham. They are made of steel throughout and are of the centre discharge type. The hopper, which has a capacity of approximately 613 cubic feet, is divided transversely by a partition, making two separate compartments, each fitted with two hinged bottom doors. The doors, which are 4ft. 10in. long, are operated from either side of the wagon by means of a screwed shaft, working through levers to give any desired width of opening up to 2ft.

One of the plough brake vans is illustrated above. The van portion of the body contains the usual equipment of stove, brake column, lockers, lamp tray, and lamp board. At each end of the van is a platform, on which is erected the gear for supporting and for raising and lowering the ploughs. These platforms—the sides of which are boarded half way up—are accessible either from the van or from the ballast. On each platform is a hinged locker for storage of tools, &c. The body is secured to a steel underframe built from 12in. by 3½in. by ½in. and 12in. by 3½in. by ½in. channel sections. At each end the underframe members are so arranged as also to accommodate the ploughs. The centre portion of the frame houses two ballast weights. The principal dimensions are:—Length over headstocks, 21ft.; length over buffers, 24ft. 5in.; width between solebars, 6ft. 2½in.; wheel base, 9ft.; buffer height, 3ft. 5½in.; wheels (diameter on tread), 3ft. 2in.; journals, 9in. by 4½in.; width of plough 8ft. 3in.; length over body, 21ft. 1½in.; width over body, 7ft. 6in.; width over projections, 8ft. 6in.; height to top of roof, 11ft. 2½in.; weight, 16 tons.

On one of the first occasions on which a train of twelve of these wagons and a plough brake van was used, the complete operation of discharging the ballast from the wagons and distributing it evenly between and on either side of the rails for a distance of about 950 yards, by means of the plough brake van, was accomplished in thirteen minutes, the discharging gear on the wagons being operated by eight men. This train was loaded with material supplied by the Bardon Hill Quarries, and the point of discharge was on the up main line of the Midland Division between Oakley and Sharnbrook.

Other instances of the efficiency of this method of ballasting are as follows:—On the Western Division, one train was unloaded in twenty minutes by four men, and another in fifteen minutes by three men; on the Eastern Division, trains unloaded in thirteen minutes by eight men and in eight minutes by twelve men, respectively, are recorded, while on the Northern Division a train was unloaded in eight minutes by six men.

The operation of loading the wagons with ballast is also rapid. At Penmaenmawr Quarries recently a complete train of twelve wagons was placed in position in twenty minutes and fully loaded in forty minutes, only three men being employed.

We are indebted to Mr. A. Newlands, chief civil engineer, and Mr. W. A. Stanier, chief mechanical engineer, L.M.S. Railway, for permission to reproduce the illustration.

THE AUTOMATIC STABILISATION OF SHIPS.

WE have received from Schenectady some brief particulars concerning a new system for the automatic stabilisation of ships, which has recently been demonstrated by Dr. E. F. W. Alexanderson, of the International General Electric Company. So far as our information enables us to gather, Dr. Alexanderson derives his stabilising moment from fins shaped like streamline rudders, which are attached to the two sides of the ship. A moment acting to heel the vessel to one side would be counteracted by a downward tilt of the fin on that side, accompanied by an upward tilt of the fin on the other. It is to be inferred that the stabilising reaction is derived from the actual tilting movement of the fins, and that it is not, as in the Motora system described in our issue of June 27th, 1930, derived from the hydro-dynamical "lift" generated by the forward movement of the tilted fins through the water. If this inference is correct, the system would be capable of giving a stabilising reaction when the ship was at rest, and not only, as in the Motora system, when she was under way. The novelty of Dr. Alexanderson's method lies in the means employed for controlling and effecting the movement of the fins. The actual movement of the fins is produced by means of electric motors. The current to these motors is controlled by means of a very small gyroscope working in conjunction with a thyratron relay equipment. The gyroscope is employed purely for governing, through the thyratron equipment, the instants at which current shall be admitted to or cut off from the motor circuits. Its reaction is not used directly to counteract the heeling moment, as it is wholly or in part in the Sperry, Schlick, and Fieux systems. Dr. Alexanderson's method has so far apparently been tested only on a model scale, but it is stated to have worked very satisfactorily. It would appear that the gyroscope and thyratron detecting and amplifying equipment is expected to be applicable to a wide variety of controlling purposes. Its association with moving fins is not the only method contemplated for achieving the automatic stabilisation of ships. An alternative method indicated in the source of our information consists of employing the equipment to effect the desired stabilisation by moving weights from side to side of the ship, as, for example, by pumping water from one wing tank into another. In this way Dr. Alexanderson would seek to achieve by mechanical means the degree of stabilisation realised automatically and non-mechanically in the Frahm anti-rolling tank system.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Industrial Situation.

REQUIREMENTS of iron and steel for consumption are on about the same level as during recent weeks, and Midland and Staffordshire producers have no difficulty in supplying industry's needs. At the present rate of production, there is no big surplus of material going into stock, but in the raw iron department blast-furnacemen are unable to dispose of the whole of their output. While in the heavy engineering industries of the area there is little increased momentum, in the lighter departments of manufacture some progress is definitely being made, and when present stocks of material have been used up the iron and steel market should be beneficially affected. At date the call for material is of a restricted nature, orders being confined to small tonnages. These, however, have, of course, to be repeated with greater regularity than if orders were of greater bulk. Staffordshire producers of iron and steel have to meet severe competition from foreign rivals, and in one or two instances readjustment of prices have recently occurred. The relative position of native and foreign iron and steel is much as it has been for months past, but it is confidently anticipated that further legislation will prove to be to the advantage of the home producer, and that as a consequence he may expect a larger share than formerly of the available home business. Speculation is rife as to the degree of protection which will be afforded British iron and steel manufacturers, and the Government's decision is earnestly awaited. There are few sales of foreign material taking place in this area just now, manufacturers' requirements being fully covered. The weekly meeting of the iron trade in Birmingham this week was moderately attended. There were no developments of importance.

Optimism in Automobile Industry.

The automobile engineering industry in Coventry, Birmingham, and other Midland centres continues to advance. In recent years Whitsuntide has often marked the peak of the selling season, but though nearly three weeks have passed since the holidays, there is as yet no sign of any slackening off. Indeed, the overseas trade is reported to be on the up grade. A number of firms have a considerable amount of work on hand, especially in the light car branch. In this department most firms are reasonably busy. One Coventry firm reports the outlook, both at home and abroad, to be "very bright." This firm's export trade so far this season shows an increase of 500 per cent. as compared with the corresponding period last year. A bigger output is looked for next season, and arrangements are already in hand to make this possible. Makers of commercial vehicles and of passenger vehicles are moderately engaged. Works in the Black Country supplying components for the automobile trade have experienced better trading conditions during the past two months. This has brought fairly good business to a wide range of small factories throughout this area.

Heavy Edge Tools.

There has been a further slight improvement in the heavy edge tool industry in this district during the last month, and at one factory at least additional hands have been engaged. While overseas demand has not come up to normal dimensions, and has been patchy in character, it is said to have exceeded the unpalatable anticipations of some manufacturers. The home trade has remained fairly good during the spring season and more attention than usual has been given to this branch of the trade by firms in this area. The work secured has provided a stop-gap between the overseas buying patches and as such has served a useful purpose. Firms specialising on garden tools for the home market have done fairly well.

The Lighter Industries.

Production in the lighter industries of the Midlands and Staffordshire is gradually expanding. In some instances this is due to seasonal influences, while in others there is just a slight movement in consumer buying, consequent on the necessity for replacing articles no longer serviceable. After a somewhat slower time, the electrical engineering trades are becoming more active, and at establishments catering for the motor trades business is fairly brisk. In the hollow-ware industries, so important to this area, demand has improved, though the wrought and enamelled sections continue less well placed than the aluminium section. Export buying of the latter class of articles is on a restricted scale; nevertheless, some works are busy. Firms making gas stoves, fires, and heating apparatus are reasonably well engaged on account of the home trade. The improvement in the lock trade which set in some months ago, is maintained. The call for house locks for the building trade is not up to expectations, but the demand for locks for the motor car industry is good. There is little advance as yet in the chain and anchor trades or at the boiler works. Pump makers are working at about the same rate as during recent months. Nut and bolt firms in the Black Country who until recently manufactured chiefly for the heavy engineering trades, are seeking outlets in the electrical and automobile trades, and are meeting with a measure of success.

Pig Iron Prices.

The reaffirming of pig iron prices by the Central Pig Iron Producers' Association at their monthly meeting last week was in accordance with general anticipation, and consequently it has made no material difference to the trade position as existing in the raw iron industry in the Derbyshire, Northamptonshire, and Staffordshire districts. Blast-furnacemen are producing at recent rates, and are able to find an outlet for the greater part of their output. Much of the Derbyshire iron is absorbed by associated pipe foundries, while a not inconsiderable quantity of Northamptonshire iron is sold in Scotland and other northern markets against the competition of Cleveland furnacemen. The report recently given in this letter of the enterprise now being initiated at Wellingborough, where a modern plant is being installed to smelt Northamptonshire ore, shows there is a belief in the future progress of the industry. While at date there is only a moderate amount of activity in the engineering foundries, the light castings trade maintains a steady output. Competition is very keen, however, and representations are, I understand, being made to the authorities regarding the freedom from duty of castings of under 1 cwt. It is thought the foreigner may concentrate on these as compensation for loss of trade on the heavier classes. Forgemen in this area are not taking much material. The basis selling prices of Midland pig irons as reaffirmed are:—Northamptonshire forge, £2 17s. 6d.; No. 1 foundry, £3 5s. 6d.; No. 2, £3 4s. 6d.; No. 3, £3 2s. 6d.; No. 4, £3 1s. 6d.; Derbyshire forge, £3 1s.; No. 1 foundry, £3 9s.; No. 2, £3 8s.; No. 3, £3 6s.; No. 4, £3 5s.—delivered at stations in the Black Country and subject to rebate.

Finished Iron.

In the Staffordshire iron trade conditions are unchanged on the week. In most branches the business passing is restricted to consumers' current needs, and in the case of merchant and common bars, these are not large. Orders come in week by week, and producers are able to maintain output at recent levels. Only a percentage of the capacity is, however, employed. Competition is very keen in the Crown bar branch, but Staffordshire makers uphold recent price levels, maintaining that anything lower would be quite unremunerative. In the common bar branch a distinction is now made between bars for nut and bolt manufacture and those for use in the making of fencing. While fencing iron is quoted £7 15s., nut and bolt bars range in value from £8 to £8 10s. The latter is only paid in exceptional cases. Competing bars of Belgian origin are obtainable at £6 per ton. Wrought iron gas tube strip is steady at £10 10s. per ton delivered.

Steel.

Local steelmasters find present conditions hard. It is difficult to arrange rolling programmes owing to the odd sizes forming the orders on the books. Selling prices are firmly held at the level fixed by the Steelmasters' Association, and foreign competition in finished steel is of little account. Most of the large users in this area are members of the "Buy British" body who receive special rebates from the steelmaster. Midland constructional engineers place orders for small tonnages, the works in hand being of a minor character. Rolling stock establishments are not consuming the same quantity of steel as they were some time ago, but they continue good customers to the steelmaster. In the uncontrolled section of the steel trade—that devoted to the manufacture and sale of semis—competition from the Continent is of considerable moment. It is reported that billets have been offered to Black Country works at as low as £4 8s. per ton delivered. This is below the usual quotation, but it goes to show how keen the foreigner is at the moment to do business. Native makers have not changed their position, and they require £5 5s. to £5 7s. 6d. for their output. Staffordshire re-rollers also hold to late selling rates of £6 7s. 6d. upwards for re-rolled bars and £7 5s. upwards for all-British bars.

Galvanised Sheets.

Quotations for galvanised corrugated sheets of 24 gauge vary between £9 7s. 6d. and £9 10s., but it is asserted, export business of any size would be accepted at £9 5s., mills being anxious to secure orders in the face of severe competition from Belgian makers. Business, alike on home and overseas account, varies little in bulk from week to week.

Obituary.

I regret to have to record the death which took place on May 30th at Four Oaks, of Mr. Charles Heaton, joint managing director of William Hunt and Sons, the "Brades" Steel Works, near Birmingham. Mr. Heaton, who was born in 1864, and was unmarried, was the third son of the late George Heaton, J.P., of Church Hill, Handsworth. He was educated at Clifton College, and joined his father and two brothers in the firm of William Hunt and Sons. Until recently he was a member of the Oldbury District Council. He was a Justice of the Peace for the County of Worcester, and a member of the Birmingham Iron and Steel Exchange.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

The "Push" in China.

LANCASHIRE has a strong direct interest in the British engineering enterprise which has been formed for the purpose of developing business in engineering products with China, for of the seven concerns which form Dorman, Long and Associates (China), Ltd., two are Manchester companies, which, in their particular branches, are among the most important in the country. The two companies in question are the Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, which is represented in the China venture through its auxiliary company, the Metropolitan-Vickers Electrical Export Company, Ltd., and Beyer, Peacock and Co., Ltd., locomotive builders, Gorton, Manchester. This is not the first concerted effort that has been made by British industry to develop trade with China. Engineering concerns themselves, though on a smaller scale, have combined together for this purpose, but the present venture is both larger and covers a wider field. The Lancashire cotton industry, also, has in the past merged its interests with a view to securing a bigger share of Chinese business. All the previous efforts have suffered through circumstances, chiefly political, over which the British concerns have had no control. Whilst there is no guarantee that similar circumstances may not again prove a stumbling-block, engineering trade interests in this part of the country are hopeful that the present movement will meet with some measure of success.

Order Book Additions.

The order which the Soviet Government has placed with Beyer, Peacock and Co., Ltd., Gorton, Manchester, for a "Beyer-Garratt" type locomotive, said to be the largest ever built in Europe, is regarded here as being of great importance, less because of the order itself than of the possibility of big developments in this field. A number of Lancashire engineering firms have Russian work in hand, particularly in the machine tool branch. The tender (£261,000) of the Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, for the supply of two 75,000 kVA turbo-alternators, &c., for the Central Electricity Board, has been recommended for acceptance. Crossley Motors, Ltd., Manchester, have received an order from the War Office for fifteen six-wheeled "go-anywhere" motor vehicles.

Electricity for Industry.

During the year ended March 31st last, according to the annual report of the Manchester Corporation Electricity Committee, the number of electricity consumers in the area covered by the undertaking increased by 8598 to 76,375, the largest increase for a single year ever recorded. The output of current during the twelve months increased by 20,900,000 kilowatt-hours, compared with the previous year, to 398,600,000 kilowatt-hours. An interesting statement in the annual report is that, in spite of a further serious decline of 7,700,000 kW in engineering works consumption of electricity during the period under review, supplies for industrial power as a whole showed an encouraging increase for the year of 2,400,000 kW. On the financial side, the Electricity Department showed a surplus of £43,332 on the year's working, and this, allowing for £54,997 in respect of capital outlay, makes the surplus carried forward to next year £100,100.

Oil-engined Omnibuses.

Mr. R. Stuart Pilcher, the general manager of the Manchester Corporation Transport Department, who is this week attending the International Transport Conference at The Hague, is to visit Germany before returning to Manchester in order to gain information concerning the operation of oil-engined omnibuses. A number of this type of motor vehicle are operating on the Manchester routes, but difficulty is being experienced in connection with smoky exhausts. It is thought, so it is reported here this week, that some valuable information on this matter which will permit of a wider use of oil-engined omnibuses in Manchester will be obtainable in Germany.

Industrial Results.

Satisfactory working results for the year to the end of March last are indicated by two engineering companies in this area. Meters, Ltd., Manchester, in the period mentioned, made a net profit of £17,635, against £17,340 in the previous year, and for the fifth year in succession the ordinary shareholders are to receive a dividend of 9 per cent. In the case of Mirrlees, Bickerton and Day, Ltd., oil engine manufacturers, Hazel-grove, near Stockport, the full accounts are not available at the moment of writing, but the fact that a dividend of 2½ per cent. is to be paid on the ordinary shares indicates some improvement in the position, for in the previous year no dividend was paid. In the two years 1928–29 and 1929–30, however, the distribution on the ordinary shares was 7 per cent. on each occasion, a substantial decline in profits being reported in respect of the following financial year.

Non-ferrous Metals.

From the point of view of new low levels, price history continues to be made in certain sections of the non-ferrous metals market. A fall on balance for the week of about £1 15s. per ton in the case of standard brands of copper, largely on the strength of United States tariff news, has brought prices very low indeed, without having had any apparent influence on the demand, which, for both manufactured and raw copper, is on a quiet scale. The lack of any definite news regarding the output restriction scheme has been principally responsible for a fall in tin of rather more than £4 per ton, all the gains of the previous four weeks thus being wiped out. Here, also, buying interest has been quiet. After the relative firmness which has been in evidence in the spelter section since early in April the rather sharp decline to the extent of more than £1 per ton has been the cause of some surprise. The statistical position of spelter is better than it was, but the consuming industries, not only in this country, but also on the Continent and in the United States, are poorly placed, and there is no doubt that prices have also been influenced by the fall in copper and tin. Lead values continue to drop, and there has been a further decline of 10s. per ton. Orders for the metal have been small.

Iron and Steel.

Careful inquiry this week has disclosed few bright features on the iron and steel markets locally, and there is an almost general complaint of slow buying interest. Light castings makers are less unsatisfactorily placed than are most of the other foundry iron users, and are taking fairly steady deliveries. A week ago holiday influence was apparent to some extent, and this week general conditions have been pretty well back to where they were before Whitsuntide. Replacement contracts for pig iron have been reported, but they have been much less numerous than makers have been disposed to anticipate. There is no doubt, however, that, owing to the heavy consumption of scrap iron in the district, the aggregate movement of foundry iron does not, in itself, reflect the state of activity in the Lancashire foundry trades. For delivery equal to Manchester, Derbyshire, Staffordshire and Cleveland brands of No. 3 are main-

tained at 67s. per ton, with Northants at 65s. 6d., Derbyshire forge at 62s., Scottish at about 86s. 6d., and West Coast hematite at 81s. Bar iron is quiet at £10 5s. for Lancashire best quality bars, and £9 15s. for Crown bars. Current business in steel is largely a matter of small delivery parcels, especially to constructional engineers, who, in most instances, are short of work. Plates and bars, also, are in generally quiet demand. Makers of forgings have had a somewhat better week.

Exhibition of Machine Tools.

From Monday of next week for a fortnight Alfred Herbert, Ltd., of Coventry, will be holding an exhibition of modern labour-saving machine tools at their Manchester showroom, 2, Whitworth-street West, Knott Mill. Included in the demonstration will be a number of Zeiss optical measuring instruments and fine tools.

BARROW-IN-FURNESS.

Hematite.

The general outlook in the hematite pig iron trade is not altered much, but there is a tendency to expect slightly better business in some lines as soon as some consumers have exhausted their foreign metal. One firm has stated that it hopes to benefit from the tariff, and there is no doubt that it will do so in the long run. The business at present is mostly confined to home buyers, and there is very little going abroad. Stocks are coming down at certain works, but there is little likelihood of more furnaces being put into blast in this district. The Barrow steel departments are taking a fair tonnage every week at present, and it is hoped that they will be able to keep going. The ore trade continues to be moderate, but the fact that two furnaces are now in blast at Barrow makes the demand a little higher than a month ago. The outside demand for native sorts is not heavy at present. The steel trade continues to be quiet, and it is difficult to say at the moment how long the rail mills will be kept employed. The hoop mills are better circumstanced.

SHEFFIELD.

(From our own Correspondent.)

The Heavy Steel Trades.

THERE is not much change to report in the condition of the heavy branches of the steel trade whether productive or manufacturing. The output of open-hearth steel continues on about the same level that it has maintained for several weeks. Although much below the capacity of the furnaces, it amounts to a considerable volume on the whole. It is not becoming any easier to dispose of the output, however, as orders for large tonnages are scarce. North Lincolnshire, which produces basic steel on a large scale, has registered an improvement this year, but little progress is being shown at present. At Scunthorpe, unemployed steel workers have approached the proprietors of the Redbourne Hill works on the subject of restarting plants, and have offered to assist in financing the step by a loan from their wages. The management, while replying that the time is inopportune for restarting, have intimated that they would be disposed to do so immediately on being satisfied that the present duty on imported semi-steel is to be permanent.

Heavy Engineering and Manufacturing.

There is not a great deal doing in heavy engineering, although some orders have been booked lately. Hopes are entertained that the new combine of Dorman, Long and Associates, Ltd., which has been formed for the purpose of obtaining Chinese business for this country, will have a beneficial effect on Sheffield. The combine comprises seven well-known firms, with an aggregate capital of £30,000,000. One of them is the well-known Sheffield engineering firm of Edgar Allen and Co., Ltd., of Imperial Steel Works, and it is hoped that the new enterprise will assist this company in obtaining increased orders for several of its products, principally complete cement plants, rotary kilns, crushing and grinding machinery, and special trackwork for railways and tramways. The railway companies are still pursuing an economical policy in giving out orders for axles, tires, and springs, and the plants producing these requisites could do with a good deal more work. Trade with the shipyards is also quiet.

Lighter and Brighter.

The brighter side of the picture is to be found in the lighter departments, many of which are maintaining a good level of activity, though in some cases not equal to that of a month ago. One of the most satisfactory departments is that of stainless steel, acid-resisting, and heat-resisting steels, the output of which is on a substantial scale. Another good branch is that devoted to the supply of pressings, forgings, and alloy steel for the motor car industry, which continues to make large demands upon Sheffield. Other sections of trade which are doing well or fairly well are wire rods, wire, cold wrought strip, permanent magnets, and certain engineers' small tools. While the factories producing tools used in shipyards, railway works, and the building trades present some bad patches, a number of local tool works are fully occupied on twist drills, cutters, augers, and various kinds of very cheap tools which have hitherto been imported from the Continent. The large stocks of foreign tools in this country have now become very depleted, and the cost of fresh supplies is almost prohibitive, so that the call for home products is becoming general. The season for farm and garden tools has not been equal to last year's. There is an improved sale for hack-saws and files. The home market is taking good quantities of hand saws, but the export demand for large circular wood-cutting saws is not satisfactory.

An Ironworks Changes Hands.

It is announced by Trent Ironworks, Ltd., Scunthorpe, that their premises and plant were assigned to John Lysaght, Ltd., as from May 31st.

Tariff Questions.

It is said that a duty is to be imposed on imports of pig iron, except those from India and the Dominions. The Tariff Advisory Committee has not made a recommendation to the Treasury for this duty, but it has decided to do so. The matter has been brought forward by important British producers, who, though they stated some time ago that they did not need protection from foreign competition, now find that they do. I understand that Sheffield producers have not asked for the duty, but they will not object to it. The rate of the new duty is not disclosed, but it may be less than 33⅓ per cent. No decision has yet been received with regard to the application for a higher duty on imported cutlery.

An Important New Research.

At a provincial meeting of the Iron and Steel Institute held in Sheffield last week, one of the principal questions discussed was the heterogeneity of steel ingots, and the interesting announcement was made that Professor J. H. Andrew, Dean of the Faculty of Metallurgy in the University of Sheffield, is to carry out investigations regarding the oxygen content of steel. Dr. W. H. Hatfield, of the Firth-Brown Research Laboratories, chairman of the Heterogeneity Committee of the Institute and the National Federation of Iron and Steel Manufacturers, said at the present time it was beyond the ingenuity of research workers to give accurately either the content of oxygen or the content of non-metallic inclusions in steel. It has been arranged that certain members of the Committee should make it their particular hobby for some years to endeavour to deal with these points. Professor Andrew had undertaken, with his graduates and the facilities at his disposal, to see what could be done regarding putting the oxygen content of steel on a proper basis. If the University, after a period of time, as a result of the research under the Professor, was able to show how oxygen could be accurately and faithfully determined in steel, it would have done a very great service, and a service for which the steel trade all the world over was waiting.

Cutlery and Plate.

While general trade with retailers in these branches continues quiet, there is a good volume of work on hand in connection with the production of goods for cheap bazaars and for coupon distribution. Contracts for hotel and restaurant equipment provide an outlet for a fair quantity of high-class goods. The demand for safety razor blades, which has expanded considerably this year, continues large. Trade in scissors and cheap pocket knives, of the classes formerly imported from Germany, is still fairly substantial, but the rush of orders has fallen off since the tariff on cutlery was reduced from 50 to 20 per cent., and it is doubtful whether the present rate will have the effect of keeping out foreign goods to any considerable extent. The German firm of Gebr. Ritchartz und Sohne, of Solingen, has completed the equipment of a large factory in Sheffield for the manufacture of pocket knives and scissors. The firm proposes to cultivate a medium-class trade, and the output will consist of familiar English patterns. There has been a decline in the call for spoons and forks, but sales are still large. The demand at present is principally for the unplated variety. The economy being exercised by the public is having an unfavourable effect on the trade in electro-plated hollowware. A veteran of the silver and cutlery trades died a few days ago in the person of Mr. Thomas Cooper, one of the founders of the firm of Cooper Brothers and Sons, Ltd. He was in his ninetieth year.

The Menace of Floods.

As a result of recent heavy rains, there have been very serious floods in several parts of the Don Valley. Doncaster and the adjoining village of Bentley have been affected worst, while Rotherham has also suffered. The question of coping with the flood menace in this area is becoming very urgent, and the adoption of remedial measures on a large scale is being advocated. It has been estimated that an adequate scheme would involve an expenditure of £250,000. There is a growing opinion that the problem is too large for merely local action, and that Government assistance is required.

NORTH OF ENGLAND.

(From our own Correspondent.)

The Industrial Outlook.

TRADE development in the North of England is a slow process, but signs are not lacking that the general situation is gradually improving. In the iron and steel industry particularly, it is hoped that prospects may grow much brighter in the near future, the hope being based on the fact that the stocks of foreign material imported before the tariffs were imposed, are beginning to run out, and consumers will eventually enter the home markets for their supplies. While customers are still buying sparingly and chiefly for early delivery, the hopeful feeling has not left the market. Inquiries are neither large nor numerous, but are gradually spreading. The prevailing opinion is that values are unlikely to fluctuate, and buyers expect to be able to cover requirements as they arise at round about present prices. Under such conditions there is, of course, little inducement to buy forward.

Cleveland Iron Trade.

There is little change in the position of the Cleveland pig iron trade. The bulk of the make is going into consumption at local works, chiefly at producers' own foundries and steel works. Output is not fully absorbed, but additions to the accumulations at the blast-furnaces are not large. Producers continue to sell Cleveland pig iron in Scotland at specially low figures in order to cope with the keen competition of dealers in other irons; but to customers elsewhere fixed minimum rates stand at: No. 1 Cleveland foundry, 61s.; No. 3 G.M.B., 58s. 6d.; No. 4 foundry, 57s. 6d.; No. 4 forge, 57s.

Hematite Pig Iron.

Conditions in the East Coast hematite pig iron trade show a slight further improvement. A few more orders have been placed by Sheffield and Midland consumers, and there are inquiries from other home centres. Nearly all the transactions, however, are for small tonnages. Buyers report that they can readily purchase ordinary mixed numbers at 63s., and No. 1 quality at 63s. 6d. Hematite is thus comparatively cheap. Ordinary qualities are only 4s. 6d. above the recognised market rate for No. 3 Cleveland pig iron, whereas the normal pre-war difference was 8s. to 10s.

Ironmaking Materials.

Consumers being well stocked and having deliveries to take under running contracts, business in the foreign ore trade is exceedingly quiet. Best Rubio ore is about 15s. c.i.f. Tees. During May, 35,000 tons of foreign ore were imported into the Tees as compared with 30,000 tons in April. Durham blast-furnace coke is abundant. Sellers are anxious to liquidate their heavy stocks, but are unwilling to accept less than the basis of good average qualities at 15s. 6d. delivered at the works.

Manufactured Iron and Steel.

Further inquiries for finished steel are reported from Canada, and there is every prospect of business resulting. Departments engaged on the production of constructional steel keep busy, but most other sections are only moderately employed. Sections making railway material have a few contracts on hand. Sheet makers would welcome buying. Prices are unchanged.

The Coal Trade.

Coal exporters in the North of England have a handicap from which those in other districts of this country are exempt—the quota of British coal imported into France. The latest reduction in the quota from 70 to 60 per cent. has left the French trade more difficult than ever. Great Britain is now the only country exporting coal to France that is still subject to the import licences. Strong representations are being made by Northern coal exporters to the British Government in the hope that something may be done. Very little business is circulating for early shipment, and supplies of all descriptions of fuel remain abundant. There are some large contracts to be handled this week, but in view of the severe competition from German and Polish producers merchants do not anticipate securing more than a moderate share of the business. Prices for prompt delivery of steam coal descriptions are quoted at the schedule minimum, and for forward business similar conditions prevail. Best Northumberland steams are in ample supply for any shipment at 13s. 6d. for large and 8s. 6d. for small. Prime Wear large are nominally steady at 15s., with small firm at 12s. Tyne prime large are offering freely at 12s. 9d., but small are somewhat scarce at 9s. Other secondary qualities are weak at from 12s. to 12s. 6d., and small at 8s. Best bunker coals maintain a steady though not brisk business, best classes at 13s. 6d. and good ordinary at 13s. In the Durham gas fuel section the position continues quiet, superior qualities being taken up fairly steadily, but ordinary sorts having more buyers than sellers. Coking unscreened and small are abundant at 12s. to 13s. 9d., according to grade. Throughout the Durham coalfield there is much idle time, numerous mines being closed down and many others working only three or four days a week. The coke trade position is dull and easy, stocks being plentiful, and, although curtailed, output is more than sufficient to meet current demands. Prices are quoted unchanged, but are easy in tone. Best gas coke is 17s. 9d., patent oven coke 14s., and superior foundry coke or coke nuts 16s. to 18s.

Notices for Miners.

Because of the crippling effect on the colliery owners of the present restrictions in the mining industry, more than 1350 Durham County miners received notice to terminate their employment this week-end. The men are engaged at three collieries belonging to the Priestman group of pits. They are the Lilley Drift Colliery, Rowlands Gill; the Axwell Park Colliery, Swalwell; and the Chester South Moor Colliery, Chester-le-Street. The first and last-named pits have been working short time for many months. There is enough coal in all three pits to ensure working for years, but the coal-marketing scheme, the quota, and other restrictions, it is officially stated, make it impossible for the firm to keep working.

SCOTLAND.

(From our own Correspondent.)

Trade Outlook.

DURING the past week or two the outlook on the export side may be said to have shown signs of improvement by virtue of better inquiries from Canada and the placing of orders for Russia, in which Scotland may benefit to some extent. It has been said that there is reason to hope that Canada may in future take some of her supplies from here, which were formerly taken from the United States. It also appears probable that trade with the Far East may take a turn for the better. In the Clyde and district area, of course, the greatest hindrance to a revival is the dearth of orders for shipbuilding materials. A moderate amount of repair work is on hand but contracts for new tonnage are urgently required.

Steel.

Makers of heavy steel have only a very modest demand for plates and sections at present. Sheetmakers, on the other hand, though perhaps not quite so busy as

they were two months ago, are doing a fair turnover in black sheets and are interested in a number of inquiries which they are hopeful may materialise. Even at present the export business is considerably in excess of the turnover at this time last year. The returns, of course, are from January to the end of April, and even allowing for a slight retrograde movement during the past few weeks, the present state of the inquiry would appear to indicate that the loss will be made good in the near future. Tubes are comparatively quiet.

Iron.

Bar iron producers are still faced with keen Continental competition, and the cheaper cost of home steel products. The present tariffs are in this case hopelessly insufficient. On the other hand, the duties have increased the production costs of re-rolled steel bars, the local price being now £6 10s. and the export £6 7s. 6d. per ton. Here, again, the tariffs are far too low to strike a balance. It is hardly to be expected, therefore, that local works can do otherwise than experience a lean time.

Pig Iron.

Makers of Scottish pig iron also have to meet considerable competition from abroad. The depreciation of sterling has acted against Continental material, but Indian basic iron continues to come over in considerable quantities, and occasional lots also come from England. As a result, the output from the six furnaces in operation in Scotland is ample to meet all demands.

Scrap.

Prices of scrap show no change, cast iron machinery being quoted 47s. 6d. to 50s., and heavy steel 37s. 6d. per ton.

Coal.

Except for a certain amount of inquiry from Scandinavia, the export department is almost devoid of interest, apart from coastwise business. Fifeshire fuels are still comparatively firm, supplies being not too plentiful, owing to recent labour troubles. Lothians steams have a moderate turnover, treble nuts are firm, but smaller sizes are easy. West of Scotland sorts are affected by the advance of the season, and reduced industrial requirements, and practically all grades are readily obtainable, and prices are a matter of arrangement. Aggregate shipments amounted to 230,579 tons, against 216,098 tons in the preceding week, and 214,196 tons in the same week last year.

The Fulham Power Station Boilers.

I find that I was not strictly correct in my report last week that the order for the boiler plant for the new electricity power station at Fulham had been placed with Babcock and Wilcox, Ltd. The contract has actually been secured by the Stirling Boiler Company, Ltd., an associate of Messrs. Babcock and Wilcox. The order covers the supply of six tri-drum Stirling boilers, each having an evaporation of 260,000 lb. of water per hour, the working pressure being 625 lb. and the final steam temperature 850 deg. Fah. Air heaters, stokers, economisers, &c., are included in the contract.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

The Coal Trade.

THERE has been no movement in the steam coal trade during the past week, and many collieries have been short of the ready tonnage required to keep them working with regularity. In the case of anthracite collieries, the position has unquestionably been more favourable, though it has to be admitted that even with anthracite coals the loading pressure has not been quite as pronounced as formerly. According to the Great Western Railway Company's returns, shipments of steam and anthracite coals last week were more like normal, as the quantity reached 407,295 tons, which compared with 228,345 tons for the preceding week, which was affected by the holidays. A comparison with the corresponding period of last year is vitiated by the fact that at that time the Whitsuntide holidays prevailed, the quantity being 243,482 tons. There is no doubt that so far as last week is concerned shipments from the Channel as a whole would have been much better if exporters had been able to place suitable tonnage at the disposal of the collieries. The trouble at the moment is by no means wholly attributable to the absence of orders. Business is held, and a good deal of it is for immediate execution, but exporters have found a very real difficulty in securing prompt tonnage. Outward rates of freight have advanced anything from 6d. to 1s. per ton, and even more for some Mediterranean destinations, but this has not brought forward the tonnage necessary to enable orders to be carried out. The fact is that while owners in numerous cases are only too ready to place in commission tonnage which has been laid up, they are faced with the fact that though outward rates are unquestionably better, even this does not compensate them for the utter lack of suitable business homeward. At the end of last week the loading situation showed that there were forty-five vacant berths at the various ports. This week started with an improved position, as on Monday there were nineteen vacant berths, but on the following day things were not so satisfactory, as the total of vacant berths rose to thirty-four, though there were eight steamers waiting, of which three were at Port Talbot and three at Swansea. The day-to-day inquiry for coals does not display much alteration, but still a few new orders are coming to hand. So far as contract operations are concerned, there is nothing noteworthy in the market at the moment. The Swedish State Railways and the Lithuanian State Railways are asking for tenders for locomotive coals and a small quantity of bunker coals, but this is business that more particularly interests North Country producers and exporters, as rarely does much of it come to South Wales.

The New Mines Bill.

The new Mines Bill has not so far been reflected in any unexpected development in this district. No excitement has been aroused, though it can be said that there is opposition to every section of the measure. Coal-owners are understood to be dissatisfied with the fact that they are committed to paying existing wages for a period of twelve months, though they cannot afford them; coal exporters are opposed to Part 1 of the Act, which maintains the quota and the system of minimum prices; while the workmen are dissatisfied that the maintenance of existing wages is not legally enforced, and, further, that the hours of work are not to be reduced. There is another point so far as the coal-exporting community is concerned, and that is that the question of wages is only a temporary matter, and that in another twelve months the question will again arise and have a disturbing effect, probably, on business operations. For the moment, however, the feeling exists that no trouble will arise from the passing of the Bill, though the miners' leaders will protest very strongly. Locally, the position is that the Executive of the South Wales Miners' Federation met on Monday to consider the situation, but deferred any decision until the members had a full report of the national proceedings in London on the Tuesday. In view of the situation generally, the Executive postponed the annual conference of the South Wales Miners' Federation from the beginning of July until the third week in September. A delegate conference of the craftsmen in the South Wales anthracite district at Swansea on Saturday passed a resolution expressing dissatisfaction with any settlement that did not at least give the miners a wage equivalent to the 1914 standard, plus the subsequent increased cost of living.

Developments at Clydach Works.

An interesting official statement has been issued by the Mond Nickel Company concerning developments at the Clydach Works, where the workmen have been served with notices terminating as from June 30th existing contracts. It is stated that experiments have been carried out over an extended period with the object of improving the calcination process, as carried out at the Clydach Works. In September last an experimental calciner of a new type was put into operation, and as a result of the experience gained, it has now been decided to install a battery of six similar calciners and to couple it up to the new grinding plant recently installed. The erection of the new plant will interfere considerably with the normal running of the works, and therefore it has been decided to suspend operations for some weeks, and so enable the new construction to be proceeded with without interruption. It is felt that in the interests of the workmen generally the sooner the work is completed the better. Further, the shut-down will also enable the company to effect a necessary reduction in the present heavy and excessive stock of nickel on hand. Since the merger of the Mond Nickel Company with the International Nickel Company of Canada, Ltd., a sum exceeding £200,000 has been spent on plant modifications and improvements at the Clydach refinery, and the present scheme will entail the spending of a further substantial amount. It is anticipated that operations will cease as from July 1st next, although employment will be found for as many of the present employees as possible on the new constructional work.

Blaenavon Works.

At Blaenavon, where there are three blast-furnaces and a battery of seventy-two coke ovens, rumours were recently afloat that important developments were pending, but as yet there is nothing new to announce regarding the reopening of these works. The position is that for some months reconditioning work at the blast-furnaces and coke ovens has been proceeding, the object being, of course, to prevent deterioration of plant and to keep it in a condition ready for the time when there can be a resumption of operations. The desire to be ready to take advantage of the time when trade improvement develops is a natural and commendable one. Meantime, it is interesting to note that South Wales continues to receive large quantities of iron and steel from the Continent, although Continental manufacturers are losing £2 a ton on supplies brought into this country, the price for bars being £4 2s. to £4 4s. per ton, or 11s. to 13s. per ton below the net price of Welsh bars.

Coal Tippers' Wages.

Swansea coal tippers decided last week-end to accept the new national agreement providing for a maximum reduction of 10 per cent., equivalent to 6s. per week in the minimum rate of wage, and the tippers at Cardiff, Penarth, and Barry were due to meet at Cardiff on Wednesday to consider the matter, after which the men's leaders meet the representatives of the Great Western Railway Company. Negotiations have been proceeding for some time with regard to the guaranteed weekly minimum wage of tippers, amounting to £3 per week, in South Wales.

Electrical Developments.

The Electricity Committee of the Cardiff City Council adopted a new switchgear scheme, estimated to cost £15,500, this decision being come to subject to the approval of the Electricity Commissioners at a meeting on Monday. The engineer (Mr. Morley New) had reported to the Electricity Committee that in view of the approaching completion of the "Grid" equipment for South Wales and the West of England under the national scheme of electrification, the Electricity Commissioners had informed him that provision should now be made at the Cardiff power station for switches capable of dealing with 500,000 kVA, the Central Electricity Board bearing the cost of the switches connecting to the "Grid."

Current Business.

Operations on the steam coal market continue on hand-to-mouth lines, and for the moment there is comparatively little activity ahead, though it is considered that the prospects of business expanding will be better when matters affecting conditions in the coalfield are settled, as they are likely to be very shortly. Nominally prices of all grades of coal remain unchanged at the minima. As regards business for France, there has been no development of note, though there appears to be as much dissatisfaction among the French importers of British coals as there is among the exporters on this side with the existing limitation of imports of British coals, and the system of licensing. Coke is a rather slow market, but patent fuel works are fairly well stemmed. In the case of Crown patent fuel, the price has been advanced to 20s. per ton, owing to the increase in the price of pitch. Pitwood is freely offered at recent prices.

Petters' Annual Exhibition.

During the whole of this week Petters, Ltd., of Yeovil, have been holding an exhibition of oil engines for marine and industrial purposes. Visitors to the works were enabled to see the methods of manufacture which the company employs in its production of oil engines and aircraft, and, in addition, were enabled to inspect the design of composite plants, such as oil-engine driven winch sets, generators, portable and stationary air compressors, spraying plants, and many other forms of combined equipment. Included among the exhibits were examples of the company's new two-stroke, high-speed oil engine, with independent scavenge pumps, a 4-ton lorry and a light shunting locomotive, both the second-named units being equipped with the new two-stroke engine.

LAUNCHES AND TRIAL TRIPS.

ZENDA, single-screw steel boat; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of Zenda Shipping Company, Ltd.; dimensions, 248ft. by 39½ft. by 16ft. 10in.; to carry cargo. Engines, triple-expansion, pressure 180 lb. per square inch; constructed by the builders; trial trip, May 24th.

B. O. DAVIES, Tees pilot cutter; built by William Gray and Co., Ltd., to the order of Tees Pilot Cutter Company, Ltd.; dimensions, 107ft. 10in. by 23ft. 1½in. by 11ft. Engines, triple-expansion, 11in., 18in., 30in. diameter by 22in. stroke, pressure 184 lb. per square inch; constructed by the builders; trial trip, May 30th.

ERIN, steamship; built by Workman, Clark (1928), Ltd.; to the order of Erin Steamship Company, Ltd.; dimensions, 431ft. by 54ft. 9in. by 33ft. 9in.; to carry passengers and fruit. Engines, triple-expansion, 28½in. by 47½in. by 57in. by 57in., and 51in. stroke, pressure 260 lb. per square inch; constructed by the builders; trial trip, recent.

BERGANGER, single-screw motor ship; built by Netherland Shipbuilding Company; to the order of Messrs. Westfal-Larsen and Co. A/S; dimensions, 456ft. by 61ft. by 39ft.; to carry cargo. Oil engines constructed by A.E.G., Berlin; launch, April 30th.

BROOK, single-screw steamer; built by Cammell, Laird and Co., Ltd.; to the order of the Corporation of Trinity House; dimensions, 121ft. 6in. by 26ft. 6in. by 13ft.; to act as pilot vessel. Engines, vertical triple-expansion, pressure 180 lb. per square inch; constructed by the builders; launch, May 5th.

DUCHESS OF HAMILTON, triple-screw steamer; built by Harland and Wolff, Ltd.; to the order of London, Midland and Scottish Railway Company; dimensions, 271ft. by 32ft. by 10ft. 7in.; to carry passengers on the Clyde. Engines, turbines; launch, May 5th.

CATALOGUES.

LUNKEN COMPANY, Ltd., 35, Great Dover-street, S.E. 1.—Booklet on hand tachometers and tachographs.

COLVILLES, Ltd., 195, West George-street, Glasgow.—A booklet on some of the firm's special steels and pig irons.

TAYLOR, TAYLOR AND HOBSON, Ltd., Stoughton-street Works, Leicester.—General catalogue of engraving machines and their accessories.

BRITISH ALUMINIUM COMPANY, Ltd., Adelaide House, King William-street, E.C. 4.—A brochure on powdered and granulated aluminium.

LAYCOCK ENGINEERING COMPANY, Millhouses, Sheffield.—A folder giving the specification and uses of the "Lodemore" industrial truck.

BRITISH STANDARDS INSTITUTION.—On the occasion of the annual general meeting of the British Standards Institution, which is to be held on June 9th, a luncheon has been organised, at which the President of the Board of Trade, the Right Hon. Walter Runciman, the High Commissioners for Canada, Australia, India, Newfoundland, and the Irish Free State, and a number of other distinguished guests, will be present. Mr. C. le Maistre, the Director of the Institution, who has been making a tour of the Dominions at the instigation of the Board of Trade for the purpose of developing co-operation between the standardising bodies in the various Dominions, with a view to the Empire unification of specifications, &c., will reach England on June 6th, and the luncheon will provide a suitable opportunity for welcoming him back after a seven months' tour.

BEILBY MEMORIAL AWARDS.—From the interest derived from the invested capital of the Sir George Beilby Memorial Fund, at intervals to be determined by the administrators representing the Institute of Chemistry, the Society of Chemical Industry, and the Institute of Metals, awards are made to British investigators in science to mark appreciation of records of distinguished original work, preference being given to investigations relating to the special interests of Sir George Beilby, including problems connected with fuel economy, chemical engineering, and metallurgy. Awards are not made on the result of any competition, but in recognition of continuous work of exceptional merit, being evidence of distinct advancement in knowledge and practice. The administrators of the Fund are the President, the Honorary Treasurers, and the Secretaries of the three participating Institutions, who will meet in the latter part of June, and will be glad to have their attention directed to outstanding work of the nature indicated. Communications should be addressed to the Convener, Sir George Beilby Memorial Fund, Institute of Chemistry, 30, Russell-square, London, W.C. 1, not later than Tuesday, June 14th.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. COAST—	
(1) Native	16/6 to 20/–
(1) Spanish	17/– to 22/6
N.E. COAST—	
Native	18/– to 21/–
Foreign (c.i.f.)	15/–

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) SCOTLAND—		
Hematite	3 8 6	—
No. 1 Foundry	3 12 0	—
No. 3 Foundry	3 9 6	—
N.E. COAST—		
Hematite Mixed Nos.	3 3 0	3 3 0
No. 1	3 3 6	3 3 6
Cleveland—		
No. 1	3 1 0	3 1 0
Siliceous Iron	3 1 0	3 1 0
No. 3 G.M.B.	2 18 6	2 18 6
No. 4 Foundry	2 17 6	2 17 6
No. 4 Forge	2 17 0	2 17 0
Mottled	2 16 6	2 16 6
White	2 16 6	2 16 6
MIDLANDS—		
(c) Staffs.—	(*Delivered to Station*).	
All-mine (Cold Blast)	—	—
North Staffs. Forge	3 1 0	—
„ „ Foundry	3 6 0	—
(c) Northampton—		
Foundry No. 3	3 2 6	—
Forge	2 17 6	—
(c) Derbyshire—		
No. 3 Foundry	3 6 0	—
Forge	3 1 0	—
(3) Lincolnshire—		
No. 3 Foundry	—	—
No. 4 Forge	—	—
Basic	—	—
(4) N.W. COAST—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	3 15 6 (*a*) 4 0 6 (*b*) 4 5 6 (*c*)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
SCOTLAND—		
Crown Bars	9 15 0	9 5 0
Best	—	—
N.E. COAST—		
Iron Rivets	11 5 0	—
Common Bars	9 5 0	—
Best Bars	10 5 0	—
Double Best Bars	10 15 0	—
Treble Best Bars	11 5 0	—
LANCS.—		
Crown Bars	9 15 0	—
Second Quality Bars	8 5 0	—
Hoops	12 0 0	—
S. YORKS.—		
Crown Bars	9 15 0	—
Best Bars	10 15 0	—
Hoops	12 0 0	—
MIDLANDS—		
Crown Bars	9 0 0 to 9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	8 0 0 to 8 10 0	—
Gas Tube Strip	10 10 0	—

STEEL. (*d*)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) SCOTLAND—		
Boiler Plates (Marine)	9 0 0	8 10 0
„ „ (Land)	—	—
Ship Plates, ¼in. and up	8 15 0	7 15 0
Sections	8 7 6	7 7 6
Steel Sheets, ¼in.	7 15 0	7 15 0
Sheets (Gal. Cor. 24 B.G.)	10 15 0	10 0 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. COAST—		
Ship Plates	8 15 0	7 15 0
Angles	8 7 6	7 7 6
Boiler Plates (Marine)	10 10 0	—
„ „ (Land)	10 0 0	—
Joists	8 15 0	7 7 6
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5s.
Hard Billets	7 2 6	—
Soft Billets	5 10 0	—
N.W. COAST—		
BARROW—		
Heavy Rails	8 5 0	—
Light Rails	8 10 0 to 8 15 0	—
Billets	6 10 0 to 9 0 0	—
MANCHESTER—		
Bars (Round)	9 7 6	—
„ (Small Round)	7 0 0	—
Hoops (Baling)	10 0 0	9 15 0
„ (Soft Steel)	9 0 0	8 15 0
Plates	8 17 6 to 9 2 6	—
„ (Lancs. Boiler)	8 12 6	—
SHEFFIELD—		
Siemens Acid Billets	9 2 6 (basis)	—
Hard Basic	8 2 6 and 8 12 6	—
Intermediate Basic	6 12 6 and 7 2 6	—
Soft Basic	6 0 0	—
Hoops	9 10 0 to 9 15 0	—
Soft Wire Rods	7 10 0	—
MIDLANDS—		
Small Rolled Bars (all British)	7 5 0 to 7 15 0	—
Small Re-rolled Bars	6 7 6 to 6 10 0	—
Billets and Sheet Bars	5 5 0 to 5 7 6	—
Galv. Sheets, f.o.b. L'pool	9 7 6 to 9 10 0	—
(2) Staffordshire Hoops	9 10 0	—
(*d*) Angles	8 7 6	—
(*d*) Joists	8 15 0	—
(*d*) Tees	9 7 6	—
(*d*) Bridge and Tank Plates	8 17 6	—
Boiler Plates	8 7 6 to 8 10 0	—

NON-FERROUS METALS.

SWANSEA—		
Tin-plates, I.C., 20 by 14	f.o.b.	14/6 to 15/0
Block Tin (cash)		118 17 6
„ (three months)		121 0 0
Copper (cash)		25 15 0
„ (three months)		25 15 0
Spanish Lead (cash)		9 15 0
„ „ (three months)		10 5 0
Spelter (cash)		11 8 9
„ (three months)		11 12 6
MANCHESTER—		
Copper, Best Selected Ingots		31 0 0
„ Electrolytic		32 0 0
„ Strong Sheets		59 0 0
„ Tubes (Basis Price), lb.		0 0 9½
Brass Tubes (Basis Price), lb.		0 0 8¾
„ Condenser, lb.		0 0 11
Lead, English		12 0 0
„ Foreign		10 7 6
Spelter		11 17 6
Aluminium (per ton—raw ingot)	£95	

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	2/3½ per lb.	
Ferro Tungsten	2/– per lb.	
Ferro Chrome, 4 p.c to 6 p.c. carbon	£25 12 6	7/6
„ „ 6 p.c. to 8 p.c.	£24 10 0	7/–
„ „ 8 p.c. to 10 p.c.	£23 15 0	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£37 10 0	12/–
„ „ „ 1 p.c. carbon	£47 7 6	14/–
„ „ „ 0·70 p.c. carbon	£52 0 0	14/–
„ „ „ carbon free	1/1 per lb.	
Metallic Chromium	2/9 per lb.	
Ferro Manganese (per ton)	£11 0 0 for home	
„ „ „	£11 10 0 for export	
„ Silicon, 45 p.c. to 50 p.c.	£13 15 0 scale 5/– per unit	
„ „ 75 p.c.	£18 7 6 scale 7/– per unit	
„ Vanadium	12/6 per lb.	
„ Molybdenum	6/3 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£250 to £255	
Ferro Cobalt	8/3 per lb.	

FUELS.

SCOTLAND.

	Export.
LANARKSHIRE—	
(f.o.b. Glasgow)—Steam	13/–
„ „ Ell	14/3
„ „ Splint	14/3 to 15/6
„ „ Trebles	11/6
„ „ Doubles	9/9
„ „ Singles	8/9
AYRSHIRE—	
(f.o.b. Ports)—Steam	12/–
„ „ Jewel	16/6
„ „ Trebles	12/–
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—Steam	11/– to 12/–
Screened Navigation	16/6
Trebles	12/– to 14/–
Doubles	10/– to 10/6
Singles	8/9
LOTHIANS—	
(f.o.b. Leith)—Best Steam	11/– to 11/6
Secondary Steam	11/–
Trebles	11/– to 11/6
Doubles	10/–
Singles	8/9

(8) N.W. COAST— ENGLAND.

Steams	21/9
Household	32/6 to 51/8
Coke	20/– to 22/6
NORTHUMBERLAND—	
Best Steams	13/6
Second Steams	12/3 to 12/6
Steam Smalls	8/6
Unscreened	12/6 to 13/–
Household	27/– to 39/–
DURHAM—	
Best Gas	14/6
Second	13/3 to 13/6
Household	25/– to 37/–
Foundry Coke	24/–

SHEFFIELD—	Inland.	
Best Hand-picked Branch	25/– to 26/–	—
South Yorkshire Best	20/– to 21/–	—
Derbyshire Best Bright House	20/– to 21/–	—
Screened House Coal	16/– to 17/6	—
Best Screened Nuts	16/– to 17/–	—
Small Screened Nuts	13/6 to 15/6	—
Yorkshire Hards	16/– to 19/–	—
Derbyshire Hards	16/– to 18/–	—
Rough Slacks	8/6 to 9/6	—
Nutty Slacks	7/– to 8/6	—
Smalls	5/– to 6/–	—

Blast-furnace Coke (Inland) 12/– to 12/6 on rail at ovens
Furnace and Foundry Coke (Export), f.o.b., 15/6 to 17/6

(9) SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Smokeless Large	19/6 to 19/9
Second Smokeless Large	18/9 to 19/6
Best Dry Large	19/– to 19/6
Ordinary Dry Large	17/9 to 18/3
Best Black Vein Large	18/3 to 18/6
Western Valley Large	17/9 to 18/–
Best Eastern Valley Large	17/7½ to 17/9
Ordinary Eastern Valley Large	17/3 to 17/6
Best Steam Smalls	13/– to 13/6
Ordinary Smalls	11/– to 13/–
Washed Nuts	19/– to 25/–
No. 3 Rhondda Large	19/6 to 19/9
„ „ Smalls	15/– to 16/–
No. 2 „ Large	17/– to 17/3
„ „ Through	15/6 to 16/–
„ „ Smalls	14/– to 14/3
Foundry Coke (Export)	22/6 to 36/6
Furnace Coke (Export)	17/– to 18/–
Patent Fuel	19/– to 20/–
Pitwood (ex ship)	19/– to 20/–
SWANSEA—	
Anthracite Coals:	
Best Big Vein Large	36/– to 38/6
Seconds	27/– to 32/6
Red Vein	22/6 to 27/6
Machine-made Cobbles	41/6 to 48/6
Nuts	40/– to 48/6
Beans	28/6 to 32/6
Peas	19/6 to 21/–
Breaker Duff	8/6 to 9/6
Rubbly Culm	8/3 to 8/9
Steam Coals:	
Large	20/– to 20/6
Seconds	18/– to 20/–
Smalls	11/6 to 13/–
Cargo Through	16/– to 17/6

(1) Delivered. (2) Net Makers' Works. (3) f.o.b. Makers' Works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire. (6) Home Prices—All delivered Glasgow Station. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham. (*d*) Rebate: Joists (minimum), 22/6; Ordinary Ship, Bridge, and Tank Plates and Sections, 15/– if home consumers confine purchases from associated British Steel Makers. (*e*) Delivered Black Country Stations.

French Engineering Notes.

(From our own Correspondent in Paris.)

The Industrial Slump.

UNTIL lately there has been a tendency to minimise the importance of the industrial depression, and to point to low unemployment figures as evidence that the situation is not so bad as in other countries. Those figures are, however, entirely misleading, and no one knows what is the extent of unemployment, because it has been the policy of manufacturers to reduce the number of working hours rather than to discharge men, with the result that a large proportion of workers hardly earn sufficient for a bare existence. The last week or two has seen a rapid acceleration of the decline. Except in those industries that profit more or less from public works activity there is a general collapse, and hardly anywhere is there evidence of much business being done. Although this is generally the busiest season for the motor car industry, one of the biggest factories has temporarily been shut down, and it is stated that it may be closed for two months. In another big works the production is only about one-tenth of the normal. The suddenness of the collapse has destroyed the feeling of hope that the import restrictions and other measures for the protection of home industries would have enabled manufacturers to tide over the period of depression. The phenomenal contraction of foreign trade, the declining traffic receipts, the heavy fall in revenue from taxation and other evidences of economic trouble have at length convinced the French that there can be no recovery except by strong international effort.

Iron and Steel.

The annual report of the Comité des Forges, presented by the general secretary, Monsieur Desportes de la Fosse, is of quite a different character from that of the preceding year, and for the first time it speaks of the "really frightful" acceleration in the decline of iron and steel production. While during 1931 there was a contraction of only 11 per cent. in the output of steel and of 10 per cent. in that of pig iron, the fall had suddenly increased by the end of March this year to 43 per cent. for steel and 38 per cent. for pig iron, so that the proportionate decline was nearly the same as in Germany and the United States. The figures given for Great Britain show that the contraction in the output of steel in the same period was only 6 per cent., while the pig iron production increased by 20 per cent., which is the only case of an increase in any of the figures. The orders placed in France for merchant bars in March dropped to 38 per cent. of what they were a year ago and for joists to 43 per cent., while for rails and sleepers the situation was much worse. Since 1930 export prices have fallen 50 per cent. Much of the trouble is attributed to the protectionist policy of Great Britain which, it is said, is likely to have an incalculable effect upon the conditions of production in France. The heavy fall of prices on the home market has been arrested by the grouping of steel producers, who have agreed to abide loyally by the quotas of production to be fixed by a triumvirate for a period of three years. This scheme has been rendered possible only by the import quotas, which are, nevertheless, regarded as a temporary expedient until some more acceptable method of mutual exchanges can be devised.

The Seine Reservoirs.

The plan to construct reservoirs on the upper reaches of the Seine with a view to regulating the level of the river and preventing floods in and around Paris is making so much progress that the first instalment of the works on the river Cure and its affluents is nearly completed. As a means of flood prevention in this particular case, the efficiency of the reservoirs cannot be taken for granted, but they will serve some useful purpose in providing hydro-electric energy and also in supplying Paris with water in the improbable event of the city being obliged to draw upon those resources. The works now being completed comprise the dams and power stations on the Crescent, Malassis, and Chaumeçon. The Crescent dam has a height of 38 m. above the foundation and is 180 m. long. Its width at the top is 8 m., and provides for a road across the submerged valley. It is proposed to complete the first part of the undertaking and ascertain the utility of the reservoirs and the prospect of remunerating capital out of the supply of electrical energy before proceeding with the rest of the programme. From the point of view of flood protection, the scheme appears to be less necessary than when it was first put in hand, for works have been carried out simultaneously for the removal of obstructions on the Seine, and dams below Paris have been rebuilt with larger sluices.

Continuous Brakes.

When the Government decreed that all goods trains should be equipped with continuous brakes, it was decided to order one-half of the brakes from Germany on account of reparations and the remainder from French makers, and as the Government allowed long credits on easy terms for reparation material, all the railway companies, except the Nord, placed contracts for German brakes. In the present state of things the railway companies are anxious to push forward with the brake equipment, so as to provide work in their own shops and give employment to French firms which have to supply the brake accessories. The German makers, however, refuse to deliver the brakes unless they are paid for by the companies, thereby implying that they refuse to recognise any further reparation obligations. The equipment of goods trains with continuous brakes is therefore likely to be suspended until the matter can be discussed at the forthcoming Lausanne Conference.

Shipbuilding.

The new Transatlantic liner "Champlain" recently left the Saint-Nazaire shipyard and went to Havre, where it is being prepared for its first voyage to New York next month. There now only remains on the stocks the 73,000-ton liner, which will be completed in September, and there is no other merchant tonnage under construction in any of the shipyards in France.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

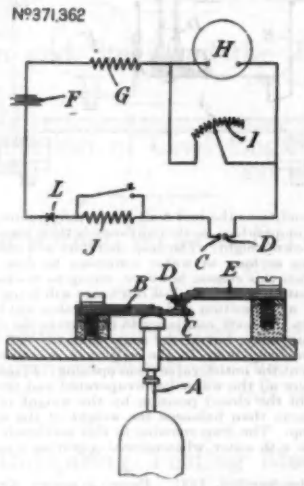
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

371,362. January 20th, 1931.—ELECTRICAL MEANS FOR MEASURING THE FUEL INJECTION PERIODS OF INTERNAL COMBUSTION ENGINES, Joseph Lucas, Ltd., of Great King-street, Birmingham; Ernest Ansley Watson and John Andrew Laird, both of the same address.

The object of this invention is to provide simple means whereby the injection period of internal combustion engines can be accurately measured so that any lack of proper adjustment can be readily detected. Use is made of the usual feeler pin or external extension A of the injection valve and an electric circuit contact breaker which can be actuated by the pin. The contact breaker may consist of a spring blade B carrying a contact C which co-operates with another contact D mounted on a fixed or a resilient part E. The contact breaker is in a circuit containing in series a small electric battery F, a resistance G, and an ammeter H. The latter is shunted by a variable resistance I which is used in making initial adjustments of the ammeter. The circuit can be opened or closed by a switch L. The contact breaker is indicated in the diagram by C D. When bringing the tester into use the switch L and contact

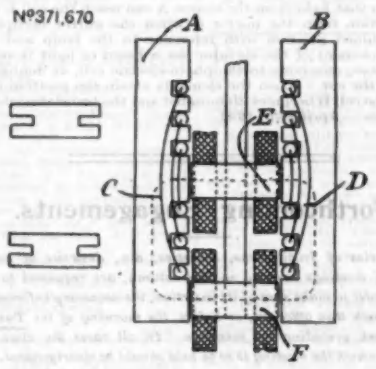


breaker C D are closed, and the resistance I adjusted so that the ammeter index is brought to a given position. This enables variations in battery voltage to be compensated. The resistance G serves to limit the current through the ammeter when the contacts are closed. Subsequently the contact breaker is operated by the feeler pin of the valve, the opening movement of the valve serving to close the ammeter circuit. A lower reading is then obtained which is proportional to the interval for which the valve remains open in each operation. The ammeter indications can therefore be used as an accurate measure of the duration of injection periods. To increase the sensitiveness of the ammeter it has been found convenient to insert an extra resistance J in the circuit when making the initial adjustment and cut out this resistance by a key when measuring the injection period. The cutting out of the resistance J enables a conveniently larger indication to be obtained on the ammeter than would be given if the resistance J were allowed to remain in action. At the same time the resistance J is necessary, in conjunction with the resistance G, to limit the ammeter reading to the scale of the ammeter when the initial adjustment is being made.—*April 20th*, 1932.

TRANSFORMERS AND CONVERTERS.

371,670. June 17th, 1931.—VOLTAGE REGULATING TRANSFORMERS, Dr. Oskar Löbl, of 2, Neue-Bismarckstrasse, Berlin-Hermsdorf, Germany.

This invention is particularly concerned with regulating transformers in which there is no alteration in the phase relation of the primary and secondary electromotive forces. The stationary

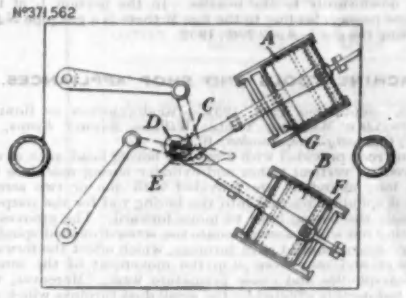


magnetic structure consists of two limbs A B, which carry the secondary windings C D in slots. The movable or adjustable structure consists of two magnetic bridge pieces E F mechanically linked together and carrying the primary windings wound in such a direction that they both set up flux in the same direction through the bridge pieces. The regulation is obtained by adjustment of the movable structure.—*April 28th*, 1932.

MEASURING AND TESTING INSTRUMENTS.

371,562. March 21st, 1931.—GAS METERS, Meters, Ltd., of Blackfriars House, Parsonage, Manchester, and William Thomas Glover, of 37, Grasmere-road, Clarkesfield, Oldham.

The object of this invention is to reduce the size of a gas meter of given capacity. The invention relates particularly to the valves and the grids or ported faces by which the gas is delivered to and from the measuring compartments of the meter. The two valves which distribute the gas to and from the opposite sides of the two diaphragms are usually set at an angle of about 90 deg. to one another, and are operated by a common crank

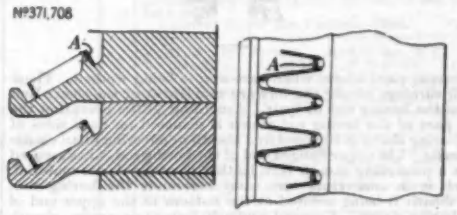


through two connecting-rods. According to the invention the valves A, B, which are of the usual slide type, are disposed at an angle between 15 deg. and 64 deg. to one another, and are operated by the two throws C, D of a common crank shaft E which is turned by the metering mechanism in the usual manner. By arranging the valves A, B at a small angle to one another, it is possible to bring the ported faces or grids F, G into a more favourable position and also to make the ports wider than usual. The meter can, therefore, be made narrower without reducing its capacity.—*April 28th*, 1932.

FURNACES.

371,708. July 24th, 1931.—MEANS FOR SUPPORTING RESISTOR ELEMENTS IN ELECTRICALLY HEATED FURNACES OR LIKE CHAMBERS, Electric Resistance Furnace Company, Ltd., of 17, Victoria-street, London, S.W. 1; and Francis George Connor, of "Imber," Court-road, Caterham, Surrey.

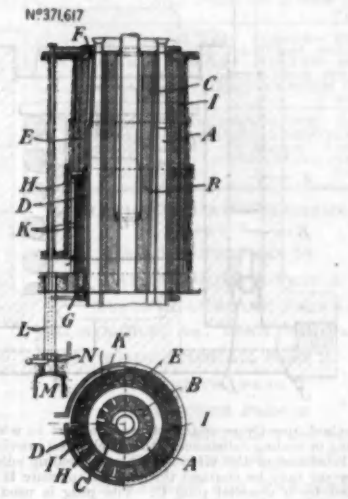
In electrically heated furnaces it is often necessary to vary the temperature gradient in the vertical direction from the floor to the roof, and for this purpose it has been proposed to connect groups of resistors provided at different levels to transformers or other sources of electric supply so that the heat emitted from the individual groups can be adjusted to meet the particular requirements. In some cases, however, it is difficult to obtain the necessary fineness of the gradient. If the resistor element consists of spirals of heavy gauge wire or rod with their axes horizontal,



the diameter of the spirals may be too large to allow the required grouping in the vertical direction, and the elements may sag and short circuit under their weight at the high temperatures to which they are normally raised. To obviate this drawback the resistor element, preferably in the form of a tape or strip, is wound, in accordance with the invention, round uniformly spaced pegs or projections A provided on downwardly inclined shelves integral with and projecting laterally from the refractory bricks forming the side walls of the furnace or chamber. The resistor elements are preferably in the form of tape or strip wound in loop form, the lower end of the loops resting edgewise on the shelf. The smaller the inclination to the horizontal the more of the resistor can be accommodated in a given vertical space, and consequently the greater the fineness of the adjustment of the heat gradient.—*April 28th*, 1932.

371,617. May 5th, 1931.—VERTICAL RETORT FURNACES, Johann Lutz, of 45, Fruhlingstrasse, Essen-Bredeney, Germany.

This specification describes a recuperatively heated vertical retort furnace for the production of gas and coke heated in a vertical direction. The vertical retort furnace chamber A of



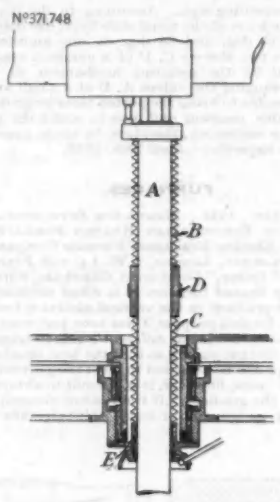
annular cross section is only heated from the outside. The inner core B is provided with the gas discharge passages C, which communicate along their entire length with the furnace chamber by means of a slot. Separate heating passages D are provided in the outer wall E. Into each separate heating passage a nozzle F is fitted at the top, and at the bottom there is a nozzle G, so

that in the same heating passage the combustion gases flow both from the bottom upwards and from the top downwards. The outflow of the combustion gases from each heating passage takes place through a separate waste gas passage H communicating with the heating passage at about the middle of the furnace. Separate air passages for the upper and lower burners of each heating passage are arranged in a circle parallel to the heating passages, but outside the latter, and receive the heat which is radiated outwardly. Air passages I for the upper nozzles F extend from the bottom upwards in a straight line adjacent the waste gas passage H, whilst the air passages K for the lower nozzles G first pass upwardly adjacent the waste gas passage to about the middle of the furnace and are then passed downwardly to the nozzles. In the portion L of the waste gas passage leading to the flue M there is a gas pipe N for preheating the gas.—*April 20th*, 1932.

MACHINE TOOLS AND SHOP APPLIANCES.

371,748. September 19th, 1931.—IMPROVEMENTS IN BORING AND LIKE MACHINE TOOLS, *William Edward Evans, of 27, Chancery-lane, London, W.C. 2.*

Boring rods provided with a moving boring head, such as are employed on vertical lathes and cylinder boring machines for boring long cylinders, are provided with one or two screw-threaded spindles inserted into the boring rod for the purpose of causing the boring head to move forward. The grooves in the boring rod which accommodate the screw-threaded spindles quickly become choked with turnings, which affect the forward movement and may even stop the movement of the screw-threaded spindles and cause premature wear. Moreover, the boring rod itself is affected by the small dust turnings which are

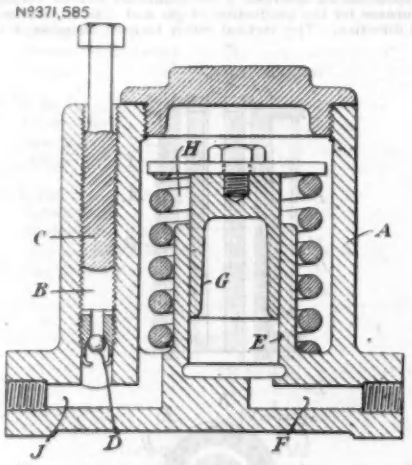


produced, particularly when cast iron is being worked. These small turnings hinder the forward movement of the sleeve and cause the boring rod to wear. According to the invention the free part of the boring rod which is disposed on both sides of the boring sleeve is enclosed in a sheath or covering of an elastic material. The upper flanged end of the boring rod A has secured to it a protecting sheath B of leather or other elastic material, which is in concertina form and surrounds the boring rod, the sheath B being secured at the bottom to the upper end of the boring sleeve. A second similarly formed protecting sheath C, which is secured to the lower end face of the boring sleeve D, is attached at its lower end to an immovable sleeve E.—*April 28th*, 1932.

MISCELLANEOUS.

371,585. April 13th, 1931.—MEANS FOR AUTOMATICALLY SUPPLYING LUBRICANTS OR OTHER VISCOUS OR PLASTIC SUBSTANCES TO RELATIVELY MOVABLE SURFACES, Robert William Leach and William Henry Bateman, both of Audley Engineering Company, Ltd., Newport.

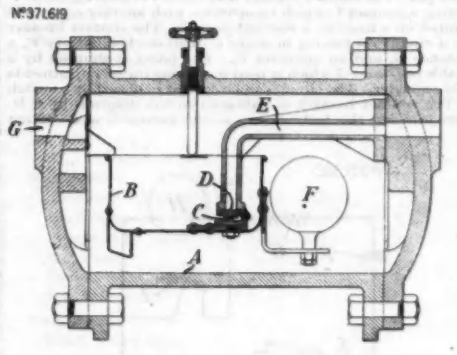
A method is described in this specification of supplying lubricant to moving parts, such as parts of machinery, movable pipe joints or couplings, hinges, valves or cocks, &c. It may also be used to supply a viscous or plastic sealing substance—which may also act as a lubricant—to prevent leakage of fluid between a pair of relatively movable or other surfaces in contact. A hollow part A adapted to be



attached directly or indirectly to the part to which the lubricating or sealing substance is to be delivered provides a reservoir for lubricant or the viscous or plastic sealing substance. This reservoir may be charged through an aperture B which can be closed by a screwed plug C. The plug is used to force the lubricant past a non-return valve D to the reservoir. Alternatively the reservoir may be charged by means of a grease gun through a nipple containing a non-return valve. Within the reservoir there is a cylinder E, which communicates by means of a pipe or passage F with any convenient source of fluid pressure, such as the fluid which it is desired to seal against leakage. A piston G within the cylinder has its outer end exposed to the reservoir, so that when moved relatively to the cylinder in the outward direction it can displace substance from the reservoir. A spring H contained within the reservoir also acts on the piston and tends to move it relatively to the cylinder in the outward direction, and by supplementing the pressure upon the lubricant or sealing medium exerted by the pressure fluid ensures maintenance of the lubricant or sealing medium at a higher pressure than that of the fluid which it is desired to seal against leakage. Under the action of the pressure fluid in the cylinder, or the spring, or both, the piston exerts pressure on the lubricant or other substance, and forces it out of the reservoir along the passage J or any other convenient passage to the part where the lubricant or sealing medium is required.—*April 28th*, 1932.

371,619. May 6th, 1931.—STEAM TRAPS, Royles, Ltd., of Dalham Engineering Works, Irlam, near Manchester, and Alan Gilbert Royle, of the same address.

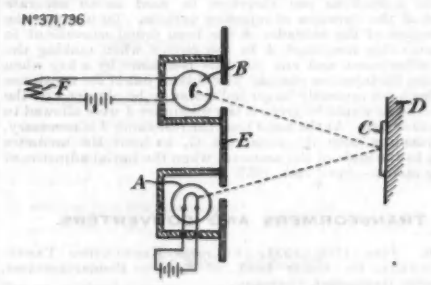
This invention relates to steam traps for draining water of condensation from steam mains, &c., which under normal working conditions carry superheated steam, but which, when being first heated up, require the draining of condensation water caused by contact of the steam with the cold mains, &c. The steam trap comprises a cylindrical chamber with flanged body part A and domed end plates, within which there is a bucket float B. In this float there is a valve member C adapted when the float is raised to enter and close a valve opening D in an outlet pipe E. Secured to the open float B is a ball float member F, which tends to keep the float raised and therefore the valve D closed. When the trap is in initial operation water of condensation will flow into the chamber through the inlet G and surround the open float B, finally overflowing into the float.



Under these conditions the ball float F is totally submerged and is accordingly inoperative, as its buoyancy is then just sufficient to support its own weight. The trap therefore will operate in a normal manner as long as water continues to flow into the chamber. When this ceases, however, owing to re-evaporation of the condensation water, the last discharge will bring the open float into its "up" position and the outlet valve will be closed. As the water in the body continues to evaporate the open float will lose its buoyancy, but at the same time the ball float will become progressively more in the nature of a counterweight, and thus prevent the outlet valve from opening. Finally a state is reached where all the water has evaporated and the valve is still retained in the closed position by the weight of the ball float, which more than balances the weight of the open float tending to drop. The trap remains in this condition until the body again fills with water, when normal operation is restored.—*April 28th*, 1932.

371,736. September 3rd, 1931.—PHOTO-ELECTRIC APPARATUS, *Westinghouse Electric and Manufacturing Company, of East Pittsburgh, Pennsylvania, U.S.A.*

This invention is particularly applicable to elevator systems, and its chief object is to provide an improved arrangement for photo-electric apparatus for the control of an electric circuit in accordance with the position of the car. The apparatus comprises a light source A with a photo-electric cell B or other equivalent radiation-responsive device. A mirror C or other light-deflecting device is mounted on an element D movable relatively to part E. The part E may be an elevator car, and D



a part of the elevator hatchway. The photo-electric cell B is connected in circuit with a battery and a translating device F, which may be the operating coil of a relay. The incandescent lamp A and the photo-electric cell B are screened by any suitable means, so that light from the source A can reach the cell B only by reflection from the mirror C when the mirror occupies a predetermined position with reference to the lamp and cell. Upon movement of the elevator car a beam of light from the lamp moves, relatively to the photo-electric cell, at double the speed of the car. When the elements attain the position illustrated, the cell B becomes illuminated and the translating device F operates.—*April 28th*, 1932.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Tuesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

INSTITUTION OF ELECTRICAL ENGINEERS.—Summer meeting at the North Midland Centre. For provisional programme see page 379.

PHYSICAL AND OPTICAL SOCIETIES.—Imperial College of Science and Technology, South Kensington, S.W. 7. Discussion, "Vision." 2.30 p.m. to 5.30 p.m., 7 p.m. to 9.30 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle-street, Piccadilly, W. 1. Discourse, "Electrical Conductivity of Metals at the Lowest Temperatures," by Mr. J. C. M'Lellan. 9 p.m.

TO-DAY AND SATURDAY, JUNE 4TH.

INSTITUTE OF TRANSPORT.—Congress at Buxton. For programme see page 523.

NEWCOMEN SOCIETY.—Summer meeting in Staffordshire. For programme see page 597.

SATURDAY, JUNE 4TH.

INSTITUTION OF ELECTRICAL ENGINEERS: SOUTH MIDLAND STUDENTS' SECTION.—Summer visit to Ironbridge Power Station. A motor coach will start from the White Horse Hotel, Great Charles-street, Birmingham, at 2 p.m.

MONDAY, JUNE 6TH.

ROYAL INSTITUTION OF GREAT BRITAIN.—21, Albemarle street, W. 1. General meeting, 5 p.m.

TUESDAY, JUNE 7TH.

SOCIETE DES INGENIEURS CIVILS DE FRANCE: BRITISH SECTION.—In the Lecture Hall of the Institution of Mechanical Engineers, Storey's-gate, Westminster, S.W. 1. "Methods of Benificiation of Carbonisation of Non-caking Coals Especially of Anthracite Dust," by Monsieur C. Berthelot. 6 p.m.

TUESDAY TO FRIDAY, JUNE 7TH TO 10TH.

INSTITUTION OF BRITISH FOUNDRYMEN.—Annual Conference at Newcastle-upon-Tyne. Particulars may be obtained from the Hon. Conference Secretary, Mr. J. W. Eckford, 4, Mosley-street, Newcastle-upon-Tyne.

INSTITUTION OF GAS ENGINEERS.—Park-lane Hotel, Piccadilly, W. 1. Sixty-ninth annual general meeting. Tuesday: Opening session, 10 a.m. Presidential address by Mr. J. Herbert Canning. Presentation of medals. Paper, "The Co-ordination of Power Relative to Gasworks," by Mr. F. M. Birks. President's luncheon to the Council, 12.45 p.m. General meeting of the Benevolent Fund, 3 p.m. Paper, "The Use of Gas as a Fuel in Industry, with Special Reference to Future Applications," by Dr. C. M. Walter, 3.15 p.m. Reception and dance, 9 p.m. to 2 a.m. Wednesday: Papers, "Ten Years' Carbonising in Vertical Retorts," by Mr. J. E. Blundell; "Gas Fire Flues and Ventilation," by Mr. C. A. Masterman, 10 a.m. Council luncheon to the President, 12.45 p.m. Visit to the works at Beckton of the Gas Light and Coke Company, 2 p.m. Thursday: Papers, "A Method of Analysing Gas Output Curves," by Dr. J. S. G. Thomas; "The Results of Constructive Policy as Applied to a Small Gas Undertaking," by Mr. W. Clark Jackson, 10 a.m. Visit to the Chemical Works and the Metro-coalite plant of the South Metropolitan Gas Company at East Greenwich, 2 p.m. Friday: Sussex tour. Leave Victoria Station, 9.20 a.m. train.

WEDNESDAY, JUNE 8TH.

INSTITUTION OF MECHANICAL ENGINEERS: THE YORKSHIRE BRANCH.—Joint meeting with the North-Eastern Branch. Visit to Middlesbrough; visit to the Acklam and Britannia works of Dorman, Long and Co., Ltd., 12.45 p.m. Constantine Technical College, Middlesbrough, paper, "Steel Works on the Continent," Mr. J. Sinclair Kerr, 5.30 p.m.

WEDNESDAY, JUNE 15TH.

STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Visit to Port of London. Leave Wolverhampton 8.7 a.m., Dudley Port 8.18 a.m., and New-street, Birmingham, 8.40 a.m.

WEDNESDAY TO FRIDAY, JUNE 15TH TO 17TH.

INSTITUTION OF MINING ENGINEERS.—Summer meeting at Sheffield. Wednesday, general meeting at the Royal Victoria Hotel, Sheffield. Address of welcome by the Lord Mayor of Sheffield. Presentation and discussion of papers, 11 a.m. The meeting will be adjourned at 1 p.m. and resumed at 2.30 p.m. Reception of members and ladies by the Lord Mayor and the Lady Mayoress of Sheffield at the Town Hall, 4.30 p.m. Reception of members and ladies at the Royal Victoria Hotel, Sheffield, by the President and Council of the Midland Institute of Mining Engineers, followed by a cabaret show and dance, 9.30 p.m. Thursday, visits to various works, 10.30 a.m. Institution of Mining Engineers' dinner at the Royal Victoria Hotel, Sheffield, followed by informal dance, 7.30 p.m. Friday, visits to various works, 11 a.m.

WEDNESDAY, JUNE 15TH, TO SATURDAY, JUNE 18TH.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Glasgow. Fifty-ninth annual general meeting and conference.

TUESDAY TO SATURDAY, JUNE 21ST TO 25TH.

BRITISH WATERWORKS ASSOCIATION.—Bournemouth. Annual general meeting and conference. For programme see page 422.

SUNDAY TO SUNDAY, JUNE 26TH TO JULY 10TH.

WORLD POWER CONFERENCE.—Sectional meeting in Scandinavia. For provisional programme see page 405.

FRIDAY, JULY 1ST.

OVERHEAD LINES ASSOCIATION.—Summer meeting at Chesham. For provisional programme see page 513.

MONDAY TO TUESDAY, JULY 4TH TO 12TH.

INTERNATIONAL ELECTRICAL CONGRESS, 1932.—Particulars may be obtained by intending British visitors from the Secretary of the Institution of Electrical Engineers, Savoy-place, Victoria Embankment, London, W.C. 2.

TUESDAY, JULY 5TH, TO SATURDAY, JULY 9TH.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.—Royal Show at Southampton.

WEDNESDAY, AUGUST 31ST, TO WEDNESDAY, SEPTEMBER 7TH.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—Annual meeting at York. President, Sir J. Alfred Ewing, F.R.S. Particulars may be obtained on application to the secretary, British Association, or to the hon. local secretaries, British Association, The Guildhall, York.

SATURDAY, SEPTEMBER 24TH.

ALL-BRITISH EXHIBITION.—Copenhagen, Denmark. Opening.

CONTRACTS.

RUSTON-BUCYRUS, Ltd., Lincoln, have received an order for five electrically-operated excavators, equipped as shovels, with buckets of one cubic yard capacity, from the Crown Agents, for use upon the new Civil Aerodrome at Singapore.

THE CAMBRIDGE INSTRUMENT COMPANY, Ltd., has secured an order, for the whole of the temperature-measuring instruments for the new Dunston power station, Newcastle-on-Tyne. The same firm has also received instructions to supply through sub-contractors a number of 18in. illuminated dial thermometers for the reheater steam pipes.